RNTAR 2.8.2 V1
RNTSF 2.6.2 V1

TACOMA SLAG STUDY
VOLUME 1

FINAL REPORT

Submitted to:

SAIC - TSC
18706 North Creek Parkway
Suite 110
Bothell, Washington 98011

Submitted by:

Keystone/NEA
12242 S.W. Garden Place
Tigard, Oregon 97223

May 20, 1991

REVISED DECEMBER 1991

5842

TACOMA SLAG STUDY

FINAL REPORT

Prepared for:

US EPA Region X
as a subcontract from
SAIC–TSC
18706 North Creek Parkway, Suite 110
Bothell, Washington 98011

Prepared by:

John E. Wade,
John A. Cooper,
and
Charles R. Lytle

Keystone/NEA
12242 S.W. Garden Place
Tigard, Oregon 97223

May 20, 1991

TACOMA SLAG STUDY

Prepared by:

Keystone/NEA
12242 S.W. Garden Place
Tigard, Oregon 97223

May 20, 1991

Approvals:

Prepared by:	John E. Wade Manager, Ambient Air Monitoring Projects	14 May 1991 Date
Project Director:	John A. Cooper, Ph.D. President	5-20-91 Date
Director of Analytical Services:	Charles R. Lytle, Ph.D. Vice President	May 14, 1991 Date

Rev.01-12/17/91

ACKNOWLEDGEMENTS

This report was prepared for the United States Environmental Protection Agency under a subcontract to SAIC (contract #16-91001582). We would like to acknowledge the substantial contributions of David Maughan, Senior Toxicologist and contract technical officer, for his advice, suggestions and constructive criticism. Dan Redline, John Moulton and Rick Hanna provided valuable help in the field work and preparation of the sampling and analysis plan. We would also like to acknowledge the contributions of Pam Bowes and Marilyn Stinnett, who typed the draft and final documents.

TABLE OF CONTENTS

1.0 INTRODUCTION

This report describes results of an investigation of concentrations of lead and arsenic in driveways and homes in the vicinity of the Tacoma smelter. Slag from the smelter has been used by homeowners in the area as a driveway surfacing and paving material. All of the homes selected for study were more than four miles from the smelter, which is no longer in operation.

The main objectives of this investigation were to:

- investigate the concentrations of lead and arsenic in residential driveways surfaced with slag
- determine the concentration of lead and arsenic in the yards of these residences
- test the levels of arsenic and lead in dust inside the selected dwellings
- compare the chemical signature of these elements found in the driveways to those found in the associated dwellings
- examine the concentration of lead and arsenic in slag, house dust and soils as a function of particle size.

This report is organized in six sections. This section defines the purpose of the report, study objectives and report organization. Section 2 provides background for the investigation and localities of the sample sites. Section 3 provides a description of the experiment and includes field sampling and laboratory procedures, as well as quality assurance methods used. Section 4 presents results from the laboratory analysis of samples and data collected in the field. Section 5 presents conclusions and recommendations for the study. A bibliography and references are presented in Section 6.

The report also has three appendices. Appendix A is a summary of the laboratory analysis report. Appendix B presents the Chemical Mass Balance Analyses. Appendix C is the Chain of Custody Record for field sampling.

Two separate volumes accompany the report. Volume 2, Sampling and Analysis Plan, provides a detailed discussion of the quality assurance plan, field standard operating procedures and laboratory standard operating procedures. Volume 3 includes miscellaneous documentation, including photocopy of the field notebook and a log of photographs taken during sampling.

2.0 BACKGROUND

Arsenic and lead, two elements associated with adverse health effects, have been identified in significant concentrations in slag deposited around a former primary copper smelter near Ruston, Washington. The smelter operated between 1890 and 1985. The former facility is within an area defined by the United States Environmental Protection Agency (EPA) as the Commencement Bay Nearshore Tideflats Superfund site and is listed on the CERCLA national priorities list. Slag from the smelter has been used by homeowners for paving and surfacing (e.g. in driveways) and for ornamental purposes.

The objective of this study was to measure the concentrations of arsenic and lead in slag deposited in driveways of homes in the Ruston-Tacoma-Gig Harbor area and to determine if these contaminants have migrated from the slag to yard soil and housedust. Contaminated soil and dust may be tracked into the home where it can settle on surfaces or objects that are contacted by people. People can also be exposed to contaminants in slag, soil and dust by breathing particles that have been released into the air by movements such as driving over a slag or dirt driveway, dusting, or digging into soil or slag. A person may ingest contaminants if hands that have come into contact with contaminated material are paced near or in the mouth. Similarly, soil may be ingested if dirty hands are used to touch food, gum, or cigarettes that are then placed into the mouth. This is of special concern for young children who often place their hands, toys and other objects into their mouths.

A typical chemical fingerprint of slag is presented in Figure 2.1. Arsenic and lead were identified as constituents of concern in slag. Both elements are naturally occurring constituents in the earth's crust, but can be toxic to plants and animals.

In this study, the concentrations of lead nd arsenic were determined in slag, soil, and housedust samples at three locations where slag was used as a driveway surface material.

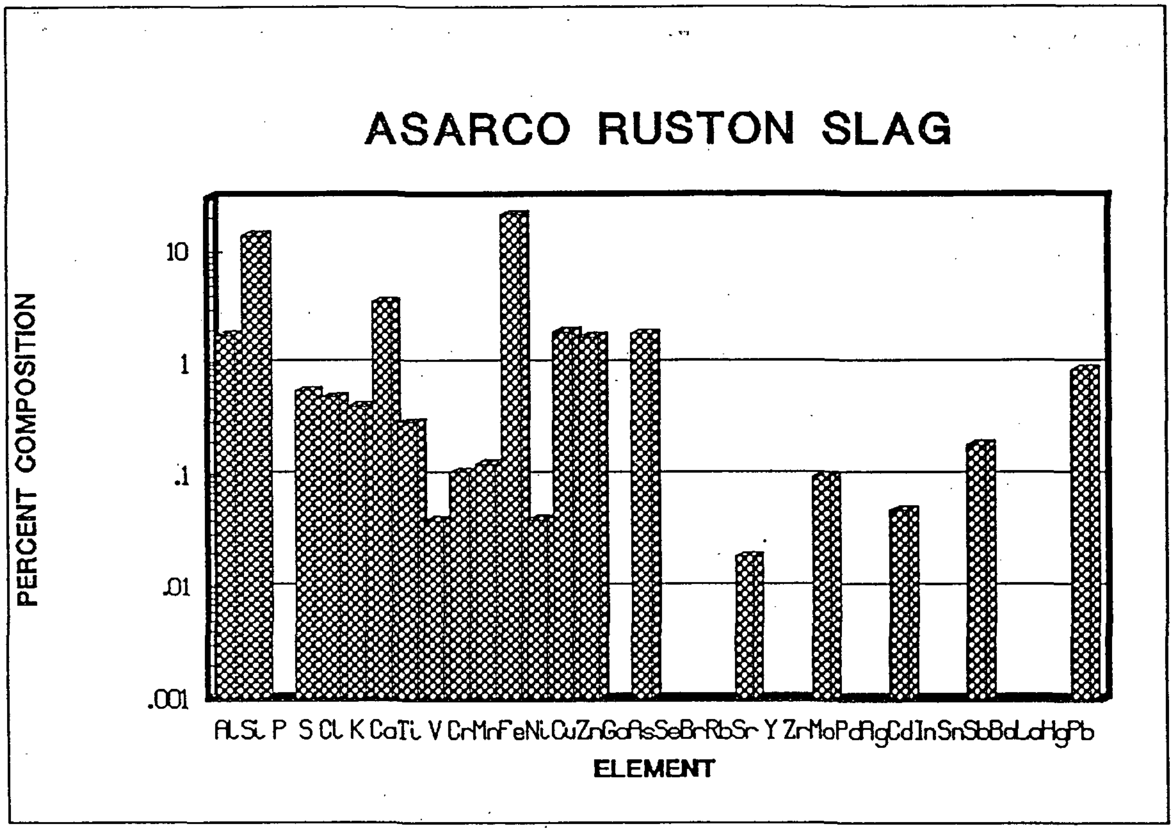


Figure 2.1 ASARCO Ruston Slag Dump Composite Material > 38 Microns

These three locations, identified as Houses 1, 2 and 3, were sampled in an area near the former Tacoma Smelter on the 27th and 28th of November, 1990 (see Figure 2.2).

An additional sampling trip was made on the 14th of December, 1990, to re-collect driveway slag at Houses 2 and 3 because samples had been inadvertently mixed in the laboratory.

Sites selected for this study were chosen because they were more than four miles from the smelter. This would have eliminated substantial airborne deposition from ASARCO stack and fugitive emissions. The sites are all generally upwind of the former smelter's location on Commencement Bay in Puget Sound. The prevailing wind direction in the area is south-southwesterly; during the summer, northeast winds become another important flow regime. Figure 2.3 shows a more detailed map of the study area. Figure 2.4 is a five-year wind rose for the area around the former smelter.

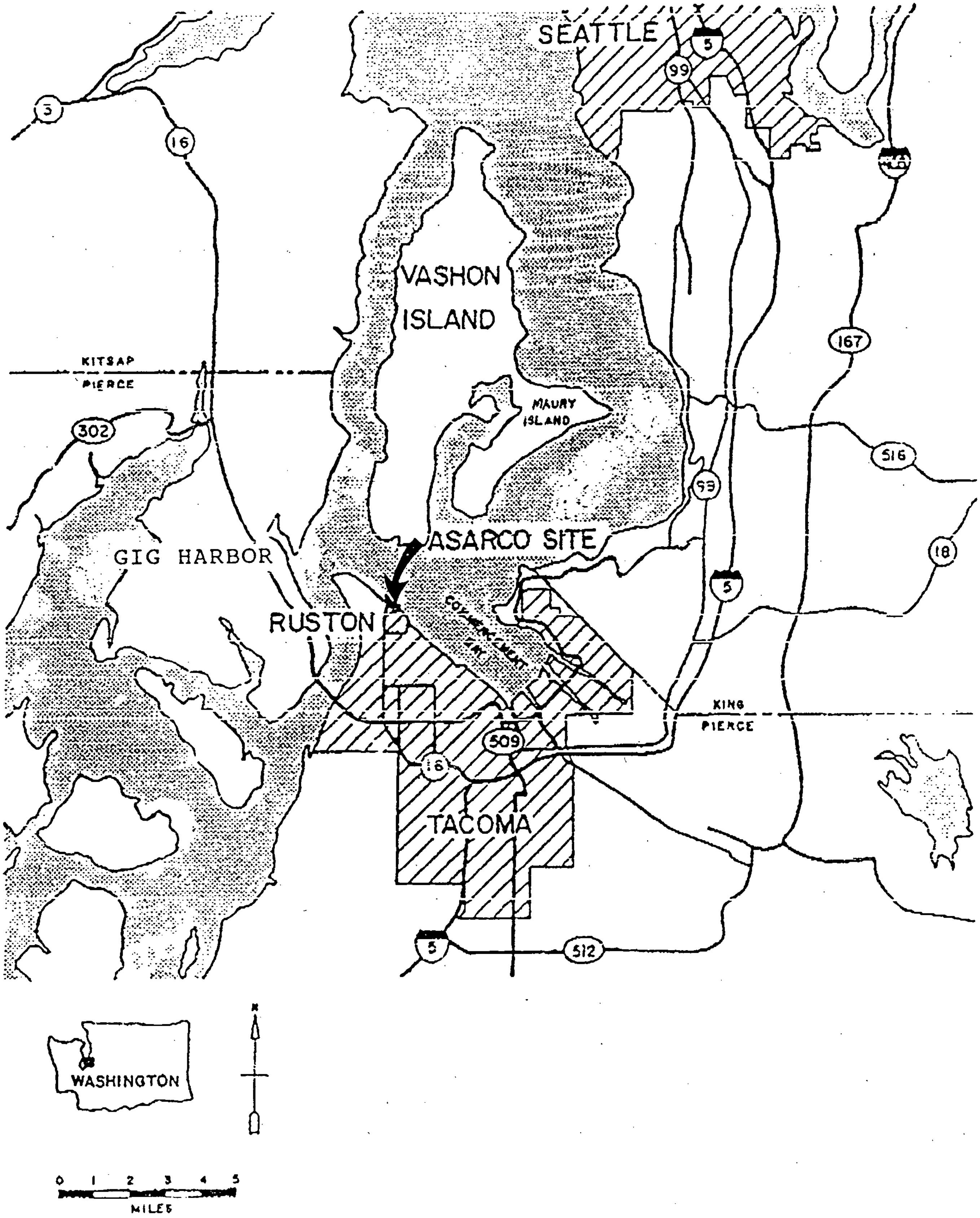
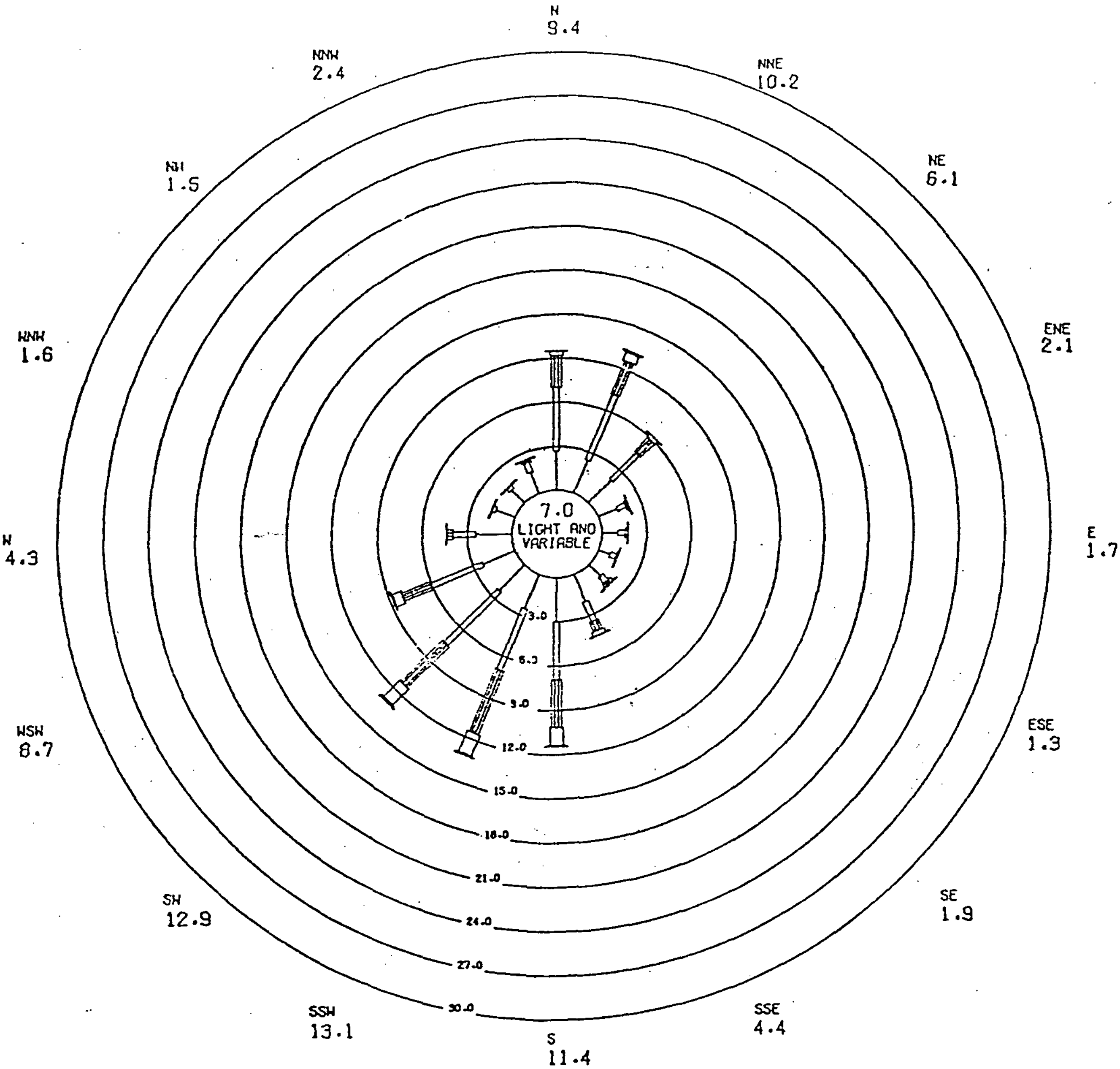


Figure 2.2 Location of sampling sites.

Figure 2.3 Detailed map of the study area.



HOUR AVERAGE SURFACE WINDS

PERCENTAGE FREQUENCY OF OCCURRENCE

STATION LOCATION- PUGET SOUND AIR POLLUTION CONTROL AGENCY
N 26TH AND PEARL STREETS. TACOMA

INCLUSIVE DATES- JAN. 1969 - DEC. 1973

TOTAL OBSERVATIONS- 43,151

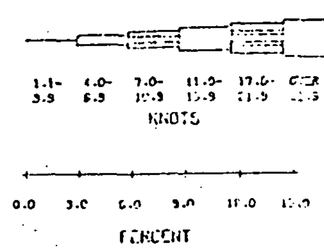


Figure 2.4 A five-year wind rose for the area near the former smelter.

3.0 EXPERIMENTAL PROCEDURES

3.1 Overview

The procedures in this section are described in greater detail in Volume 2, "Quality Assurance Plan for the Tacoma Slag Study." This section will summarize the field sampling and laboratory analysis procedures, and will discuss the techniques used to assess the precision, accuracy, completeness and representativeness of the results. Volume 3 accompanies this report and provides field notes and photographs taken during the field work.

The residences were selected by the EPA, with the primary selection criteria being sites located more than four miles upwind of the former smelter and inhabited by a cooperative homeowner. The field sampling was conducted in three different exposure media at three residences. Figure 3.1 shows a generalized diagram of the typical locations sampled at each house. The exposure media included: the <u>driveway</u>, where slag had been used as a surface paving material; the <u>yard</u>, where slag could be tracked on, leached into, and deposited from aerosolized dust; and the <u>house</u>, where soils, dust and slag could be tracked in and the dust redistributed from aerosolized dust particles.

In this investigation, dust samples from all three exposure media were divided into various size fractions prior to laboratory analysis of chemical constituents in the sample. This was done to determine if arsenic and lead concentrtions increased as the size of the particle decreased. This is important because smaller particles are the ones that can be inhaled into the lungs and that adhere to the hands.

Laboratory analysis was used primarily to determine the lead and arsenic concentration as a function of particle size. The primary laboratory analysis procedures used were graphite furnace atomic absorption (GFAA) and inductively coupled plasma spectroscopy (ICP). ICP was used to screen for lower concentrations and to detect higher concentrations. If the measured concentration was less than five times the ICP instrument

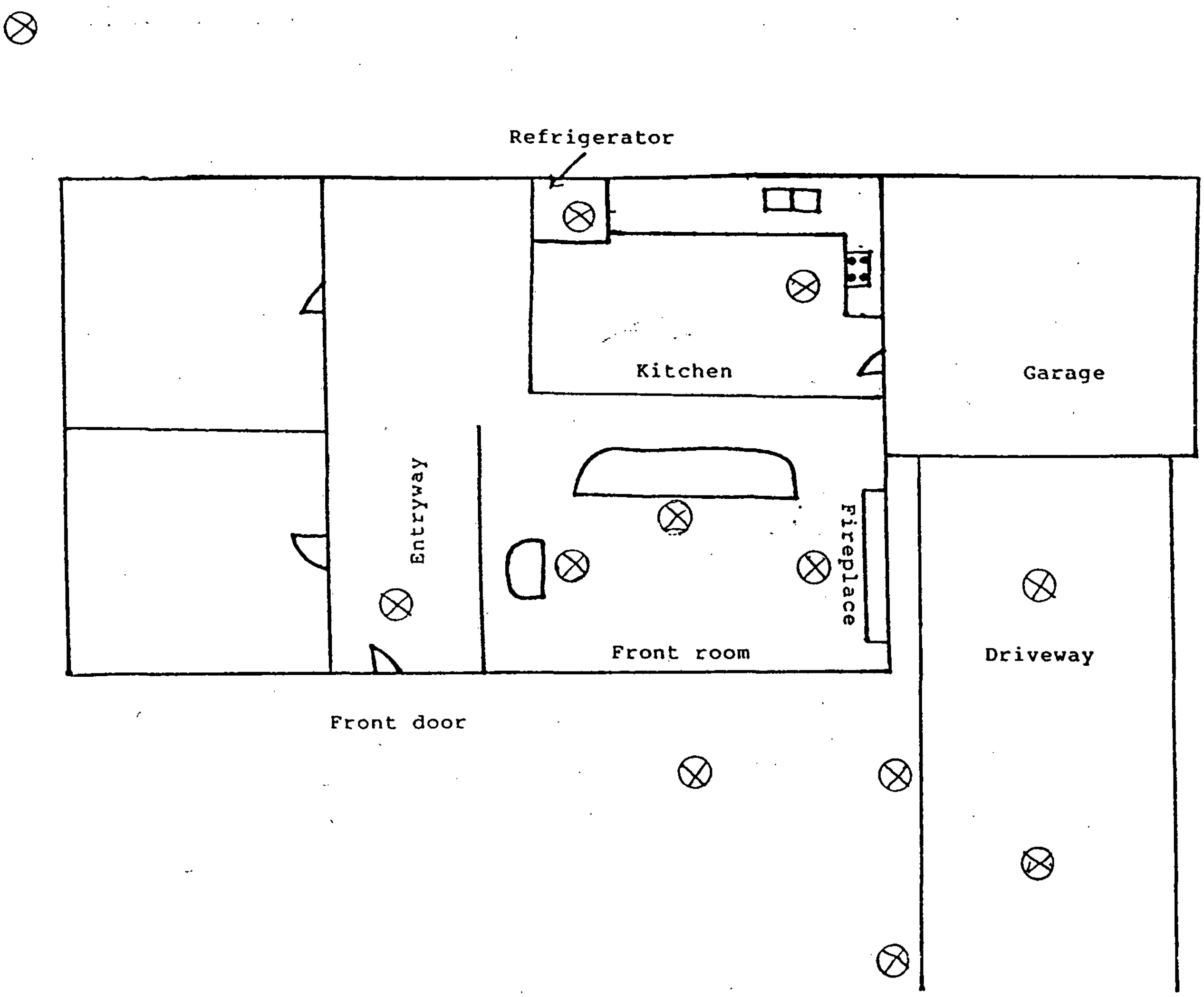


Figure 3.1 Typical Locations Where Samples Were Collected in the Tacoma Slag Study (see X inside circle).

detection limit, the sample was reanalyzed using GFAA, which is capable of detecting lower concentration levels.

Some slag samples were mechanically ground in the laboratory to determine if a difference in concentration would occur when particles were ground to a finer size fraction. The coarsest fraction (78 to 150 microns) was ground to fine powder less than 38 microns in diameter and reanalyzed to determine the effect on arsenic and lead concentrations. Additionally, chemical analysis using X-ray fluorescence was used for selected samples to compare chemical fingerprints of the residential samples to chemical fingerprints of industrial slag deposited on the driveway.

3.2 Field Sampling Procedure

3.2.1 Driveway

At each residence, slag was collected from the driveway. The procedure for sampling slag in driveways is also described in Appendix A of Volume 2, Quality Assurance Plan. Two 5-gallon acid-washed buckets were used to collect slag samples from each location. The driveway slag material closest to the surface consisted primarily of large chunks of greater than 1/4 inch in diameter. Beneath the larger chunks were smaller chunks and fine sandy and silty material. Two bulk slag samples were composited and placed in a bucket. A total of four slag plots were collected per driveway.

The depth and distribution of slag over the driveway varied with each house. The sample site selection procedure was aimed at collecting samples in high traffic areas with slag depths representative of the driveway. An area of about 2x3 feet was raked to remove large pieces of slag. Stainless steel trowels were used to scoop up the slag and place it in the bucket. The boundary layer between the slag and underlying native soil was identified by a change in the color and texture of the soil and gravel. Large particles (>1/2 inch mesh screen) were presieved using a clean piece of screen. Each bucket contained about 30 pounds of slag material after sample collection.

The buckets were sealed after sample collection with an airtight lid, and chain of custody labels were placed on each container. Equipment was washed between residential sites, and the final rinse was collected as a field blank. One bucket, taken to the Tacoma and Gig Harbor areas, was not used for sample collection, but was afterwards treated as a trip blank.

3.2.2 Yard Sampling

Four locations in the yards of each residence were sampled. The locations represented four different exposure media. These locations were:

- the most likely slag contaimination area in the driveway where slag material would be tracked or leached onto the yard [Case A];
- on a diagonal line from the driveway to teh house entrance, no more than two feet from the driveway [Case B];
- on a diagonal line perpendicular to the end or side of the driveway and no less than 18 feet from the driveway [Case C]; and
- a sheltered location on the opposite side of or though the house from the driveway [Case D];

A 40x40 inch template was laid on the ground, and soil cones were taken from each corner of the template and composited in a bag. The soil sample contained the top inch of sod or soil. The soil corer was 2.5 cm in diameter and about six inches long. After each exposure media was sampled, the soil corer was rinsed. The final rinse after completing the yard soil sampling at a residence was collected as a field blank. One duplicate sample for each medium at each house was taken to test the representativeness of the sampling procedure and the precision of chemical analyses. During the sampling, new surgical gloves were worn at each location.

3.2.3 House Sampling

Inside the house three different locations were sampled:

- Top of the refrigerator or freezer

- Kitchen floors
- Front room carpets.

Dusts on top of a refrigerator represent a historical deposition of dusts at a breathing zone of most adults. Aerosolized oil and fumes from cooking often deposit on the refrigerator top and act as a surface coating which traps airborne dust. Kitchen floors are usually not carpeted and represent current dusts as a result of a large amount of indoor foot traffic. However, they are often one of the cleanest floor surfaces in a home. The living room carpet is a location upon which small children play, crawl and lay. Carpets may appear clean, but inefficient household vacuums may leave a considerable amount of dusts, soil, skin, hair fragments, food, and microorganisms in the carpet.

The kitchen floor and refrigerator or freezer top were sampled by wiping the surface with a low metal, alcohol-dampened cellulose swab. A 10x10 inch area on the top of the refrigerator or freezer and a 20x20 inch area on the floor were selected as representative sample areas. Surgical gloves were used during sampling and changed after each sample. One duplicate sample was taken on each surface to check the representativeness of the sample site selection, and a field blank was collected by opening a swab but not performing the wipe. A laboratory blank consisted of digestion of an unused wipe.

Carpet dust was sampled using two collectors. The first was the homeowner's household vacuum cleaner, and the second was an EPA specially designed household vacuum (HVS3 = High Volume Small Surface Sampler). The design and operation of the HVS3 has been described by Roberts et al. (1991), and in Volume 2. Figure 3.2 shows an illustration of the EPA HVS3 sampler. An area 18x54 inches was sampled unless the carpet was a throw rug or entry carpet. The amount of dust collected determined how many 18x54 plots were vacuumed. The carpet in House 1 was a short plush carpet. Less than two grams was collected at four 18x54 locations. At the second residence, with a level loop carpet, nearly 35 grams were collected in four locations. House

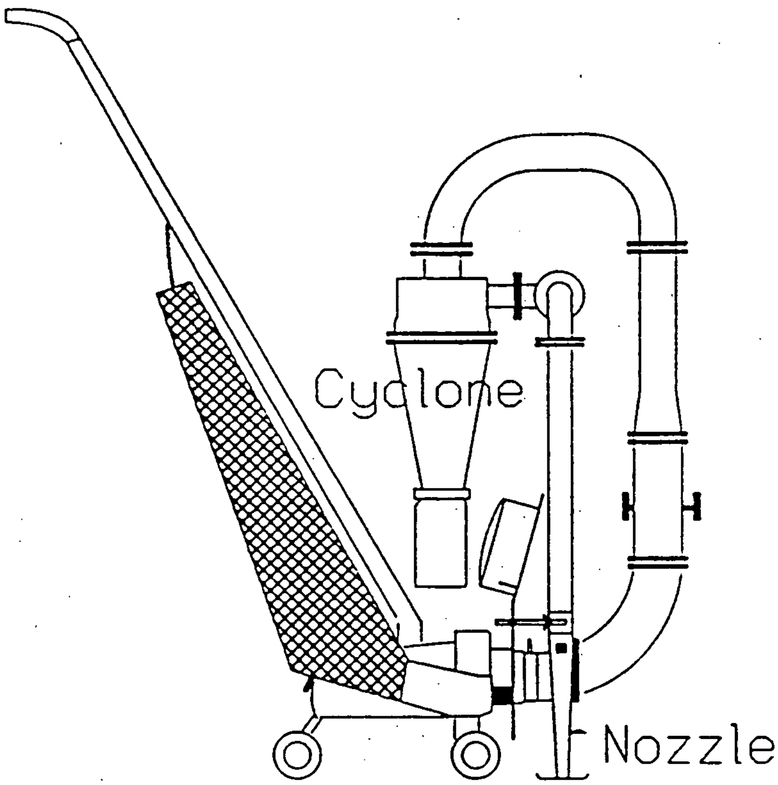


Figure 3.2 HVS3 Sampler.

3 had a very short plush carpet, and less than two grams of dust was collected in three sample locations. In House 3, a sculptured rug in an entryway yielded 8.8 grams from three 18x54 inch sample areas.

The HVS3 was cleaned between samples by running it for at least 20 seconds with intake nozzle off the carpet. Between households, the HVS3 was completely disassembled and cleaned with a 50% acetone and 50% pentane solution. The rinse was collected in a I-Chem bottle and labeled for laboratory analysis.

Samples were also collected from the household vacuum cleaner. At House 1, surgical gloves were used to remove a large handful of carpet debris and dust. At Houses 2 and 3, the entire contents of the disposable vacuum bags were collected. All three homes used upright vacuum cleaners.

3.3 Preparation of Samples for Laboratory Analyses

The driveway slag, yard soil, and dust collected from the household and EPA vacuum were dried and sieved, using a Tyler Sieve Shaker Model RX-24, into four size fractions (see Table 3.1). The sieving procedure is described in Volume 2, the Quality Assurance Plan. Prior to sieving and drying, samples were screened to remove particles and debris greater than 1/4 inch in diameter. Sample drying was done in the Blue-M Laboratory oven at 55°C until the sample no longer was losing weight with each reweighing of sample weight. The sample drying procedure is described in the SOP#026 Volume 2, Quality Assurance Plan.

As above, two 5-gallon buckets of driveway slag were collected at each residence. The two buckets were composited into one sample for each household prior to sieving the driveway slag. A coning and quartering compositing procedure is described in SOP#027 of Volume 2.

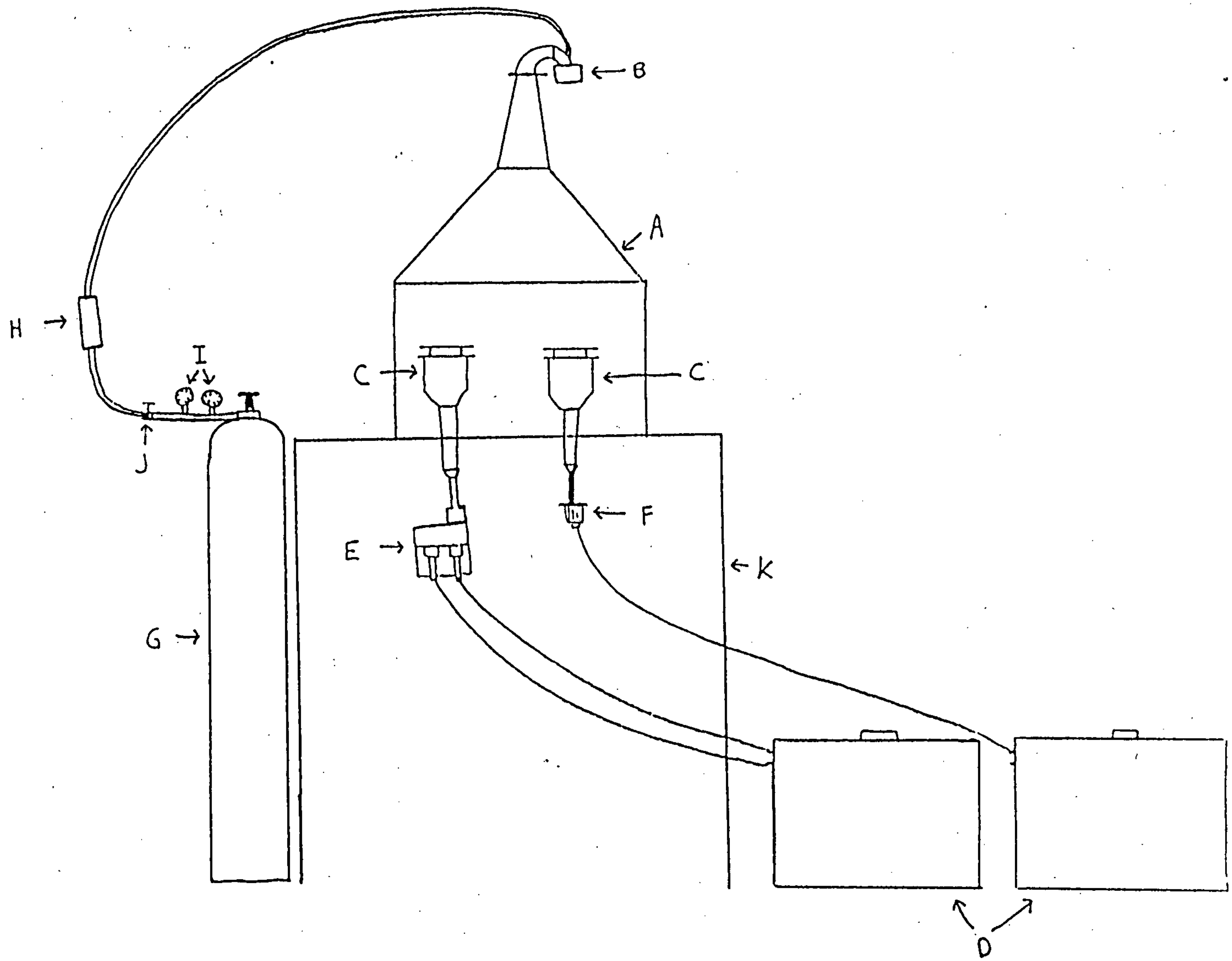
Table 3.1 SIZE FRACTIONS ANALYZED FOR CHEMICAL COMPOSITION IN THE TACOMA SLAG CHARACTERIZATION INVESTIGATION

Size Fraction	Tyler Screen Mesh Sieve	Particle Diameter (μm)
Fine (silts)	>400	< 38
Fine (sand)	400 < to 200	38 < to 75
Coarse (sand)	200 < to 80	75 < to 180
Very Coarse (fine gravel)	80 < to 18	180 < 1000

After compositing, each size fraction was weighed and relabeled. A 5 gram aliquot from each size fraction was removed from driveway and EPA vacuum collected dust samples. This 5 gram aliquot from each location was placed in sealed glass lab bottles, and sent to SAIC-TSC for further archiving. Additional aliquots were removed for grinding.

Grinding of driveway slag samples was accomplished with a ceramic mortar and pestle. Sample was ground until at least 1 gram passed through a 400 mesh Tyler Sieve. We found that slag dusts collected in the size fraction less than 180 microns were extremely difficult to grind. The dust became glassy and merely slid around. However, the size fraction greater than 180 microns could be ground for collection of some fine material. Ground sample were collected in I-Chem bottles and labeled for laboratory analysis.

Material collected in the Tyler pan below the 400 mesh sieve was weighed. If several grams were available after the SAIC 5 gram aliquot and 1 gram for ICP and GFAA analysis were extracted, then the remaining sample was aerosolized using a procedure described in Volume 2. Fine particles were resuspended onto 47mm Teflon filters using a Sierra Model 244 dichotomous sampler and special platforms, chambers and flow regulators (see Figure 3.3). The purpose of this resuspension was to obtain a thin film of slag and dust that could be analyzed by x-ray fluorescence.



- A. Resuspension Chamber
- B. Sample Cup
- C. PM-10 Inlets
- D. Dichot Pumps (16.7 LPM)
- E. Dichotomous Sampler
- F. 47 mm Filter Assembly
- G. Compressed Air (1.0 grade)
- H. In-line Hepa filter
- I. Gas Flow Regulators
- J. Three Way Valve
- K. Resuspension Platform

Figure 3.3 Resuspension Apparatus

3.4 Laboratory Analysis

3.4.1 Acid Digestion of Household Wipes, House Dust, Yard Soil, and Driveway Slag

EPA Method 3050 was used for the acid digestion of samples collected in this study. This procedure was used to prepare sediments and soil samples for analysis by graphite furnace atomic absorption (GFAA) or inductively coupled argon plasma spectroscopy (ICP). This method is appropriate for both arsenic and lead.

The method requires a 1 to 2 gram sample. The sample is digested in nitric acid and hydrogen peroxide. The digestate is then refluxed with either nitric acid or hydrochloric acid. Dilute hydrochloric acid is used as the final reflux acid. Preparation blanks are carried throughout the entire sample preparation and analytical process. Duplicate samples are processed at a 20% rate and spiked samples are employed to determine accuracy. Four outside calibration standards were provided by SAIC-TSC as a quality control check.

3.4.2 Arsenic and Lead Using ICP and GFAA

Soil samples digested using EPA Method 3050 were then analyzed by inductively-coupled plasma emission spectroscopy (ICP, EPA Method 6010) or graphite furnace atomic absorption spectroscopy (GFAA, EPA Methods 7060 and 7421).

Samples for ICP were analyzed on a Perkin-Elmer Model 40 sequential spectrometer using the instrumental and data workup guidelines stated in the EPA protocols. ICP Instrument detection limits for arsenic and lead were both 0.1 ppm. Samples with concentrations less than 0.5 ppm were reanalyzed by GFAA. GFAA analyses were done on a Perkin-Elmer Model 5000Z spectrometer equipped with Zeeman background correction and electrodeless discharge lamps. Instrumental conditions and data workup followed the guidelines given in the protocols described in the Quality Assurance

Plan for each analysis. Detection limits in the digestate were 0.001 ppm for arsenic and 0.002 ppm for lead using GFAA.

3.4.3 Elemental Analysis Using XRF

X-ray fluorescence (XRF) was used to compare the elemental composition of house dust to driveway slag. Fine material passing through the 400 mesh Tyler Sieve was aerosolized on a filter and analyzed by XRF. X-ray fluorescence as configured at Keystone/NEA is only appropriate for analysis of aerosols deposited on membrane-type filters. The procedure is described in Volume 2, SOP#010, using Protocol 4 (see Table 3.2).

3.5 Data Quality Objectives

3.5.1 Quality Assurance Objectives

The primary objective of the project QA program is to ensure that all data collected and prepared by Keystone/NEA are of known and of acceptable quality. The quality of data is known when all components are thoroughly documented and results for quality control samples fall within prescribed limits. The data must be verifiable and defensible under the scrutiny of litigation. Documented quality is the foundation of Keystone/NEA's services and provides clients with the confidence required to make difficult decisions and to take appropriate actions.

Quality assurance objectives for environmental analysis are defined in terms of the following characteristics:

- precision
- accuracy
- comparability
- representativeness
- completeness

Table 3.2 TWO SIGMA INTERFERENCE FREE DETECTION LIMITS FOR X-RAY FLUORESCENCE ANALYSIS (ng/cm^2) USING PROTOCOL 4.

Na	100	Ge	1.5
Mg	17	As	1.7
Al	15	Se	1.8
Si	11	Br	2.1
P	4.4	Rb	2.5
S	16.3	Sr	3.0
Cl	8.8	Y	3.5
K	3.9	Zr	16
Ca	2.8	Mo	12
Sc	2.0	Pd	10
Ti	1.7	Ru	12
V	1.3	Ag	14
Cr	1.6	Cd	19
Mn	1.8	In	22
Fe	2.7	Sn	25
Co	1.6	Sb	28
Ni	1.5	Ba	112
Cu	1.4	La	120
Zn	1.4	Hg	3.4
Ga	1.4	Pb	5.3
		Th	7
		U	7

These characteristics are defined below and summarized in Table 3.3. Section 4.9.2 describes the results of our Quality Assurance and the degree to which the objectives described in this section were met.

Precision

Precision is a measure of mutual agreement among repetitive measurements of the same property. Precision is calculated based on duplicate analysis. The relative percent difference (RPD) is given by:

$$[(\text{Result 1} - \text{Result 2})/\text{Mean}] \times 100$$

Accuracy

Accuracy is the agreement of a measurement (or an average of measurements), X, with an accepted reference, or true value, T. It is alternatively termed percent bias. Accuracy will be expressed as the percent recovery of the true value [100 * (X/T)]. For spiked samples, percent recovery is calculated as follows:

$$\text{Spike Recovery as } \% = \frac{\text{Sample plus Spike} - \text{Unspiked Sample}}{\text{Spike Added}} \times 100.$$

Comparability

Comparability is defined as the confidence with which one data set can be compared to another. Comparability will be evaluated when possible on the basis of interlaboratory comparisons. In order to ensure data comparability, standard analytical procedures were used, with data reported in generally accepted units of measurement. Keystone/NEA currently conducts routine interlaboratory comparison studies on the analysis of air particulates by XRF.

Representativeness

Representativeness can be defined both qualitatively and quantitatively and is dependent upon the selection of sample site and choice of sampling methods. The desired degree of representativeness is critical in planning for the collection of samples and the

Table 3.3

QUALITY OBJECTIVES FOR MEASUREMENT DATA

METHOD	MATRIX	ANALYTE	UNITS	DET. LIMIT[a]	ACCURACY TARGET	PRECISION TARGET[b]	COMPLETENESS TARGET
Gravimetry	Sieved Dust	Mass	mg	± 0.1	± 5%	± 5%	99%
	Air Filter	Mass	mg	± 0.001	± 5%	± 5%	99%
Plasma Emission Spectroscopy	Sieved Dust	Arsenic	mg/kg	2.5	± 20%*	± 20%	99%
		Lead	mg/kg	2.0	± 20%*	± 20%	99%
Graphite Furnace Atomic Absorption Spectroscopy	Sieved Dust	Arsenic	mg/kg	0.2	± 20%*	± 20%	99%
		Lead	mg/kg	0.1	± 20%*	± 20%	99%
X-Ray Fluorescence	Sieved Dust Air Filters'	Aluminum	ng/cm^2	15	± 5%	± 5%	99%
		Silicon	ng/cm^2	11	± 5%	± 5%	99%
		Phosphorus	ng/cm^2	4.4	± 5%	± 5%	99%
		Sulfur	ng/cm^2	16.3	± 5%	± 5%	99%
		Chlorine	ng/cm^2	8.8	± 5%	± 5%	99%
		Potassium	ng/cm^2	3.9	± 5%	± 5%	99%
		Calcium	ng/cm^2	2.8	± 5%	± 5%	99%
		Scandium	ng/cm^2	2.0	± 5%	± 5%	99%
		Titanium	ng/cm^2	1.7	± 5%	± 5%	99%
		Vanadium	ng/cm^2	1.3	± 5%	± 5%	99%
		Chromium	ng/cm^2	1.6	± 5%	± 5%	99%
		Manganese	ng/cm^2	1.8	± 5%	± 5%	99%
		Iron	ng/cm^2	2.7	± 5%	± 5%	99%
		Cobalt	ng/cm^2	1.6	± 5%	± 5%	99%
		Nickel	ng/cm^2	1.5	± 5%	± 5%	99%
		Copper	ng/cm^2	1.4	± 5%	± 5%	99%
		Zinc	ng/cm^2	1.4	± 5%	± 5%	99%
		Gallium	ng/cm^2	1.4	± 5%	± 5%	99%
		Germanium	ng/cm^2	1.5	± 5%	± 5%	99%
		Arsenic	ng/cm^2	1.7	± 5%	± 5%	99%
		Selenium	ng/cm^2	1.8	± 5%	± 5%	99%
		Bromine	ng/cm^2	2.1	± 5%	± 5%	99%

Table 3.3 (Continued)

QUALITY OBJECTIVES FOR MEASUREMENT DATA

METHOD	MATRIX	ANALYTE	UNITS	DET. LIMIT[a]	ACCURACY TARGET	PRECISION TARGET[b]	COMPLETENESS TARGET
		Rubidium	ng/cm^2	2.5	± 5%	± 5%	99%
		Strontium	ng/cm^2	3.0	± 5%	± 5%	99%
		Ytrinium	ng/cm^2	3.5	± 5%	± 5%	99%
		Zirconium	ng/cm^2	16	± 5%	± 5%	99%
		Molybdenum	ng/cm^2	12	± 5%	± 5%	99%
		Palladium	ng/cm^2	10	± 5%	± 5%	99%
		Silver	ng/cm^2	14	± 5%	± 5%	99%
		Cadmium	ng/cm^2	19	± 5%	± 5%	99%
		Indium	ng/cm^2	22	± 5%	± 5%	99%
		Tin	ng/cm^2	25	± 5%	± 5%	99%
		Antimony	ng/cm^2	28	± 5%	± 5%	99%
		Barium	ng/cm^2	112	± 5%	± 5%	99%
		Lanthanum	ng/cm^2	120	± 5%	± 5%	99%
		Mercury	ng/cm^2	3.4	± 5%	± 5%	99%
		Lead	ng/cm^2	5.3	± 5%	± 5%	99%

* Based on spike recovery.
[a] For ICP, assumes 1.0 g digested in 100 mL.
For GFAA, assumes 1.0 g digested in 100mL.
For XRF, assumes analysis Protocol 4.
[b] Expressed as relative percent difference when concentrations measure at least five times above instrumental detection limit.

subsequent uses of the data. Sample were collected to ensure they were representative of the component characteristics, to the greatest degree.

Completeness

Completeness is the amount of valid data actually obtained compared to the amount that was expected to be obtained under anticipated sampling/analytical conditions. If incoming data represent less than the percentage expected, sampling and handling procedures will be reviewed and appropriate steps will be taken to increase completeness. The Keystone/NEA completeness target for laboratory data is 99 percent.

4.0 RESULTS AND DISCUSSION

Table 4.1 lists all the samples collected for laboratory analysis. The following subsections include the various laboratory analyses and quality control results, as well as chemical mass balance (CMB) apportionment results.

4.1 Particle Size Distribution

Table 4.2 presents the mass in each size fraction of all the samples that were sieved. Total masses in this table represent only those analyzed. The material with a diameter larger than 1/4 inch was screened and removed from the total sample. The percent mass by size fraction also indicates that most of the mass is in the large size fractions in the driveway, while in the house the mass of particles is more evenly distributed between size fractions (see Figure 4.1). The most variability in the largest size fraction (> 180 μm) was in the EPA vacuum samples. In contrast, the least variation in the largest size fraction was in the household vacuum cleaner. In the smallest size fraction (< 38 μm), the driveway slag had the smallest variation between different locations. Samples TS1127930 and TS1127931 were duplicates and show excellent agreement in terms of size distribution.

4.2 X-Ray Fluorescence Analysis

XRF analysis was performed on four house dust samples. The purpose of this analysis was to provide a chemical signature of the slag and dust that could be used in the chemical mass balance (CMB) investigation described in this section. The only house where there was sufficient dust in the HVS3 vacuum catch to perform XRF analysis was at House 2 in Gig Harbor. The catch in the smallest size fraction (< 38 μm) household vacuum samples at Houses 2 and 3 were also sufficient to aerosolize for XRF analysis. Fine particulate (< 38 μm) in the driveway slag were also aerosolized and analyzed by XRF. The results are shown in Figures 4.2 through 4.7.

Table 4.1

FIELD SAMPLES AND QUALITY ASSURANCE SAMPLES FOR TACOMA SLAG STUDY

HOUSE 1

Id#	Sample Description
TS1127901	Refrig wipe
TS1127902	Floor wipe
TS1127903	Carpet Grab
TS1127904	HVS3
TS1127905	Vacuum rinse
TS1127906	Driveway slag
TS1127907	Driveway slag
TS1127908	Yard soil A
TS1127909	Yard soil B
TS1127910	Yard soil C
TS1127911	Yard soil D
TS1127912	Soil core rinse

HOUSE 2

TS1127913	Yard soil A
TS1127914	Yard soil B
TS1127917	Yard soil C
TS1127918	Yard soil D
TS1127915	Driveway slag
TS1127916	Driveway slag
TS1127919	Spatula Rinse
TS1127920	Soil core Rinse
TS1127921	Refrig wipe
TS1127922	Floor wipe #1
TS1127923	Floor wipe
TS1127924	Floor wipe dup
TS1127925	Vacuum grab
TS1127926	Carpet HVS3
TS1127927	Entry HVS3
TS1127928	HVS3 rinse
TS1127929	Entry HVS3 rinse

HOUSE 3

TS1127930	Yard soil A
TS1127931	Yard soil A Dup
TS1127932	Yard soil B
TS1127933	Yard soil C
TS1127934	Yard soil D
TS1127935	Driveway slag1
TS1127936	Driveway slag2
TS1127937	Wash core
TS1127938	Wash spatula
TS1127939	Vacuum Grab
TS1127940	Floor Wipe
TS1127941	Entry HVS3
TS1127942	Freezer wipe
TS1127943	HVS3 Fam rug
TS1127944	Freezer wipe Dup
TS1127945	Trip wipe blank
TS1127946	Entry Rinse HVS3
TS1127947	Fam Rug Rinse HVS3
TS1127948	Garage HVS3
TS1127949	Garage Rinse of HVS3

RESAMPLE HOUSE 2 & 3

TS1127950	Driveway slag House 2
TS1127951	Driveway slag House 2
TS1127952	Rinse
TS1127953	Driveway slag House 3
TS1127954	Driveway slag House 3
TS1127955	Trip Blank

QUALITY ASSURANCE SAMPLES

TS1127956	Standard #1 CBS CCN-1
TS1127957	Standard #2 CBS SO-2
TS1127901	Standard #3 NBS 1648
TS1127902	Standard #4 CBS PO-1

NOTE: Yard soil samples A, B, C, and D refer to definitions in Section 3.2.2.

Table 4.2

PARTICLE SIZE DISTRIBUTION IN MICRONS

			Mass (grams)					Percent			
HOUSE #	SAMPLE ID#	SAMPLE LOC	>180	>75	>38	<38	Total	>180	>75	>38	<38
1	TS1127906	DRIVEWAY	427.5	111.2	49.6	18.8	607.1	70.42	18.32	8.17	3.10
2	TS1127950	DRIVEWAY	320	74.8	41	37.7	473.5	67.58	15.80	8.66	7.96
3	TS1127953	DRIVEWAY	184.3	100.6	42.2	13.4	340.5	54.13	29.54	12.39	3.94
		MEAN	310.60	95.53	44.27	23.30	473.70	64.04	21.22	9.74	5.00
		STD	99.51	15.29	3.80	10.42	108.84	7.11	5.98	1.89	2.12
		STD ERROR	57.45	8.83	2.20	6.01	62.84	4.10	3.45	1.09	1.23
1	TS1127903	HVS3	.7	.3	.4	.05	1.45	48.28	20.69	27.59	3.45
2	TS1127926	HVS3	1.2	3.4	12.9	11.7	29.20	4.11	11.64	44.18	40.07
2	TS1127927	HVS3	.5	.1	1.9	2.6	5.10	9.80	1.96	37.25	50.98
3	TS1127941	HVS3	2.9	.13	3.4	1.2	7.63	38.01	1.70	44.56	15.73
3	TS1127943	HVS3	.4	.05	.45	.15	1.05	38.10	4.76	42.86	14.29
3	TS1127948	HVS3	2.1	.05	.6	.1	2.85	73.68	1.75	21.05	3.51
		MEAN	1.30	.67	3.28	2.63	7.88	35.33	7.09	36.25	21.34
		STD	.91	1.22	4.43	4.15	9.79	23.38	7.01	8.97	18.02
		STD ERROR	.37	.50	1.81	1.70	4.00	9.54	2.86	3.66	7.36
1	TS1127904	VACUUM	15.7	7.5	4.1	0	27.30	57.51	27.47	15.02	.00
2	TS1127925	VACUUM	141.75	60.8	61.2	23.5	287.25	49.35	21.17	21.31	8.18
3	TS1127939	VACUUM	57.4	26.8	26.8	4.5	115.50	49.70	23.20	23.20	3.90
		MEAN	71.62	31.70	30.70	9.33	143.35	52.18	23.95	19.84	4.03
		STD	52.43	22.03	23.47	10.18	107.94	3.77	2.63	3.50	3.34
		STD ERROR	30.27	12.72	13.55	5.88	62.32	2.18	1.52	2.02	1.93
1	TS1127908	YARD	8.1	5.5	2.5	.7	16.8	48.21	32.74	14.88	4.17
1	TS1127909	YARD	15	5.8	2.4	1.5	24.70	60.73	23.48	9.72	6.07
1	TS1127910	YARD	19.2	10.9	4.2	4.4	38.70	49.61	28.17	10.85	11.37
1	TS1127911	YARD	6.8	.2	5.8	1	13.80	49.28	1.45	42.03	7.25
2	TS1127913	YARD	19.9	5.4	3.8	1.3	30.40	65.46	17.76	12.50	4.28
2	TS1127914	YARD	18.1	4	.4	1.5	24.00	75.42	16.67	1.67	6.25
2	TS1127917	YARD	19.7	7	1.9	1.9	30.5	64.59	22.95	6.23	6.23
2	TS1127918	YARD	18.4	6.1	1.6	1.6	27.70	66.43	22.02	5.78	5.78
3	TS1127930	YARD	6	1.6	.1	.3	8.00	75.00	20.00	1.25	3.75
3	TS1127931	YARD	7.3	1.7	.3	.4	9.70	75.26	17.53	3.09	4.12
3	TS1127932	YARD	18.1	15.3	6	5.9	45.30	39.96	33.77	13.25	13.02
3	TS1127933	YARD	15.6	10.8	2.9	3.7	33.00	47.27	32.73	8.79	11.21
3	TS1127934	YARD	7.6	1.7	.3	.1	9.70	78.35	17.53	3.09	1.03
		MEAN	13.83	5.85	2.48	1.87	24.02	61.20	22.06	10.24	6.50
		STD	5.46	4.20	1.94	1.68	11.33	12.50	8.43	10.16	3.32
		STD ERROR	2.23	1.71	.79	.68	4.63	5.10	3.44	4.15	1.36
	YARD DUP	MEAN	6.65	1.65	.20	.35	8.85	75.13	18.76	2.17	3.94
	COMPARISON	STD	.65	.05	.10	.05	.85	.13	1.24	.92	.19
		STD ERROR	.46	.04	.07	.04	.60	.09	.87	.65	.13

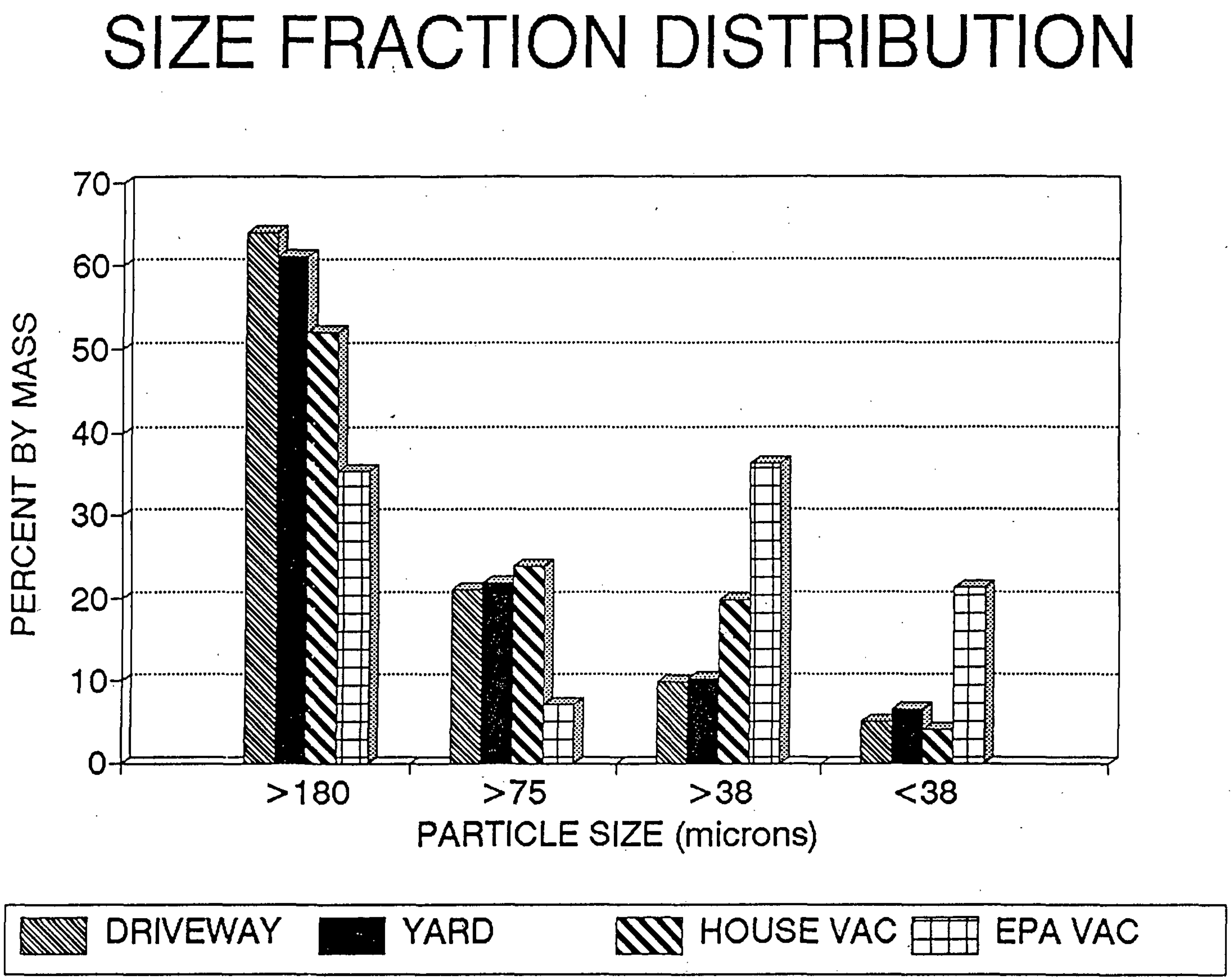


Figure 4.1 Particle Size Distribution of Soil Less than 1/4 Inch in Diameter in the Tacoma Slag Study Exposure Zones

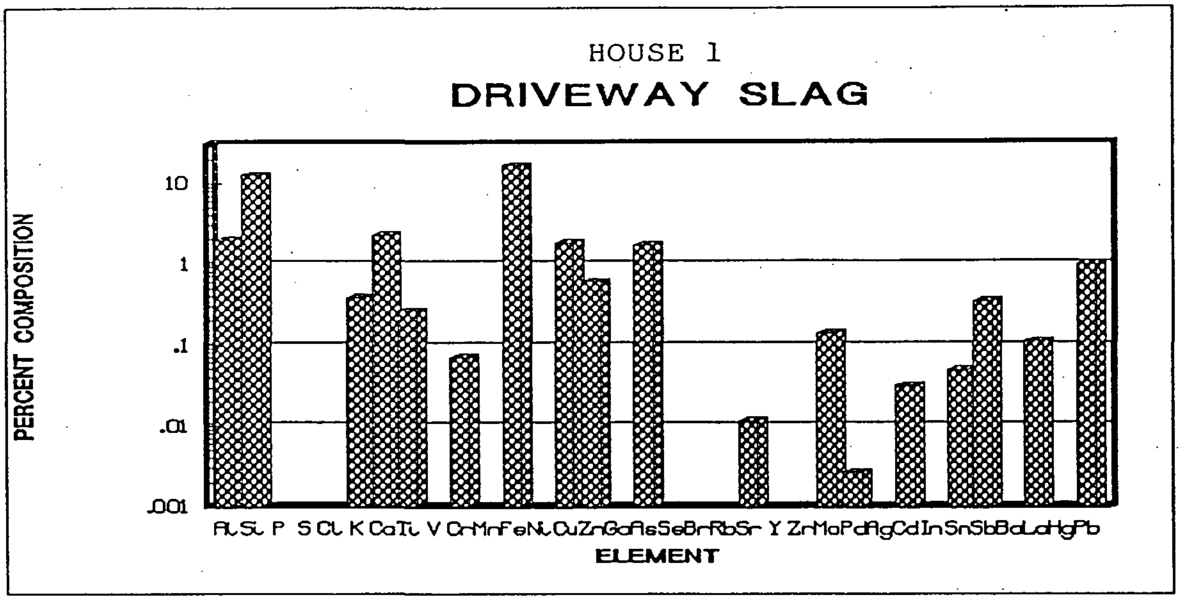


Figure 4.2 Relative Percent Composition of Elements in Driveway Slag at House 1

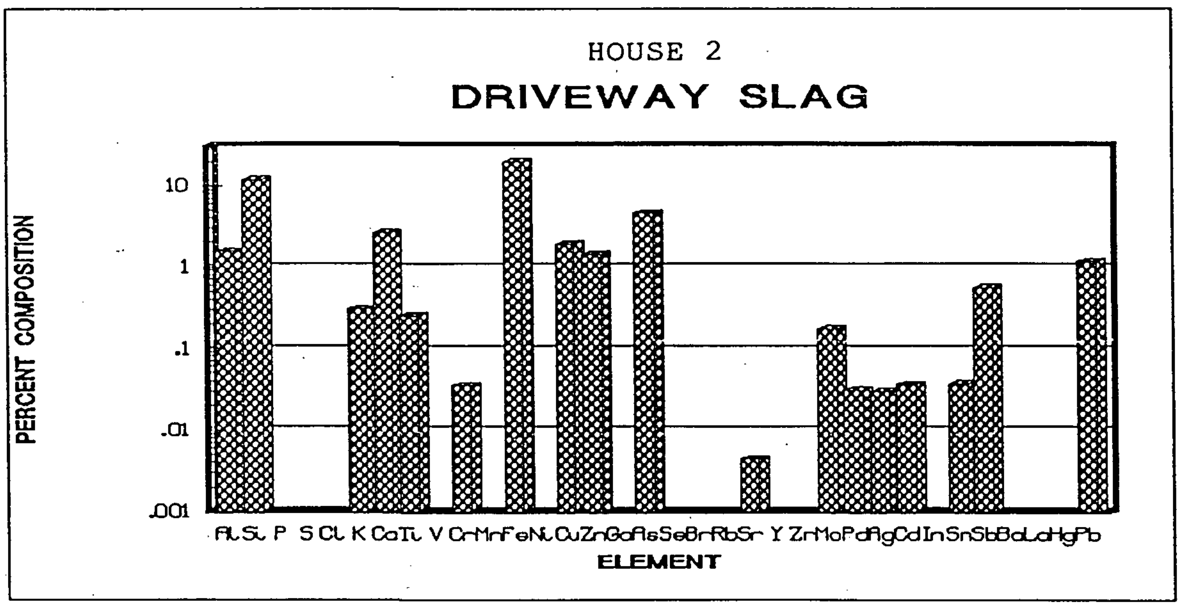


Figure 4.3 Relative Percent Composition of Elements in Driveway Slag at House 2

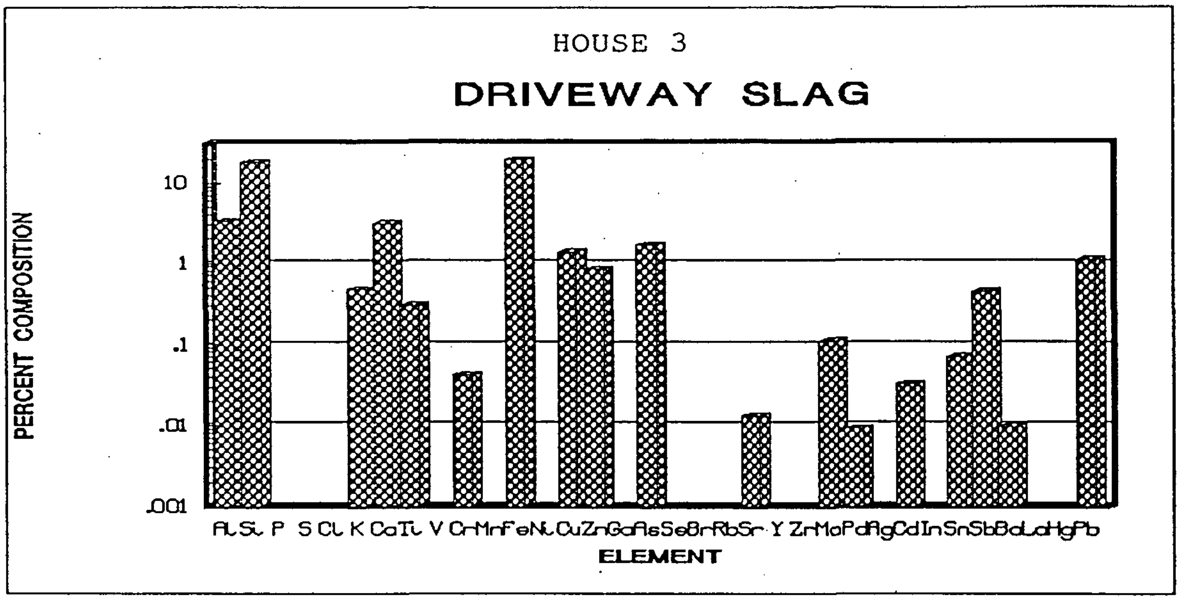


Figure 4.4 Relative Percent Composition of Elements in Driveway Slag at House 3

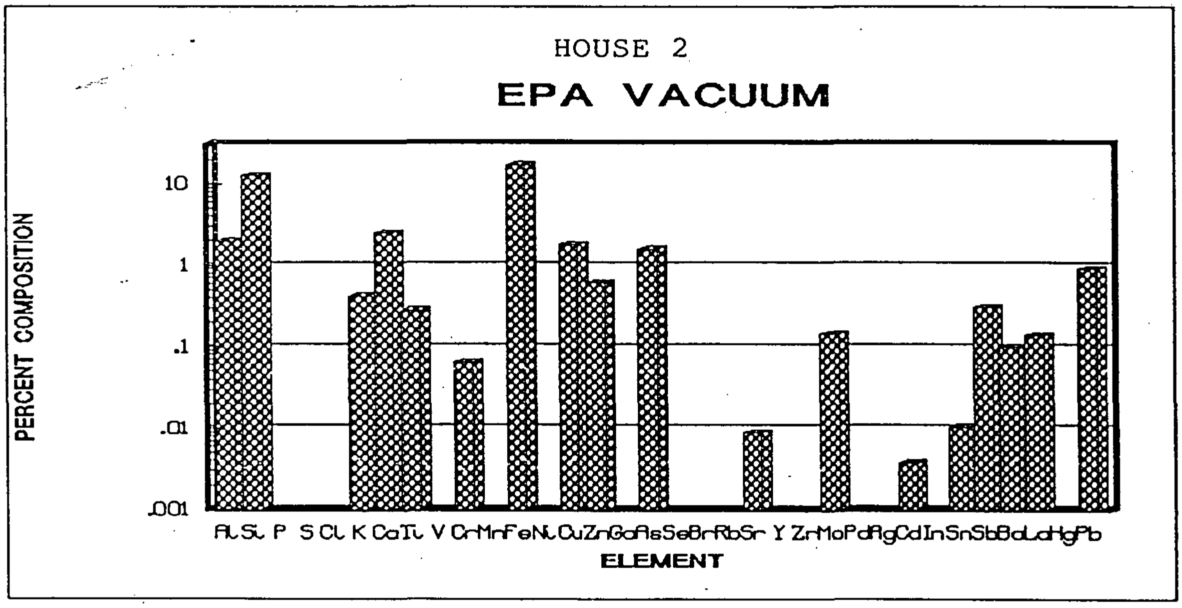


Figure 4.5 Relative Percent Composition of Elements in the EPA Vacuum Catch at House 2

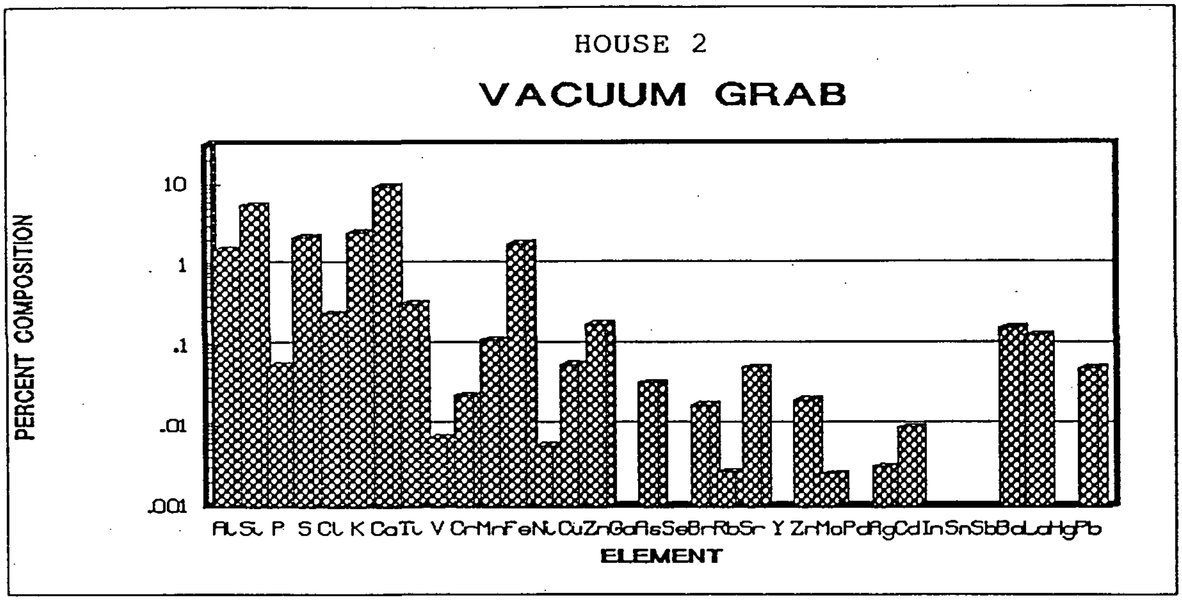


Figure 4.6 Relative Percent Composition of Elements in the Household Vacuum Grab Samples at House 2

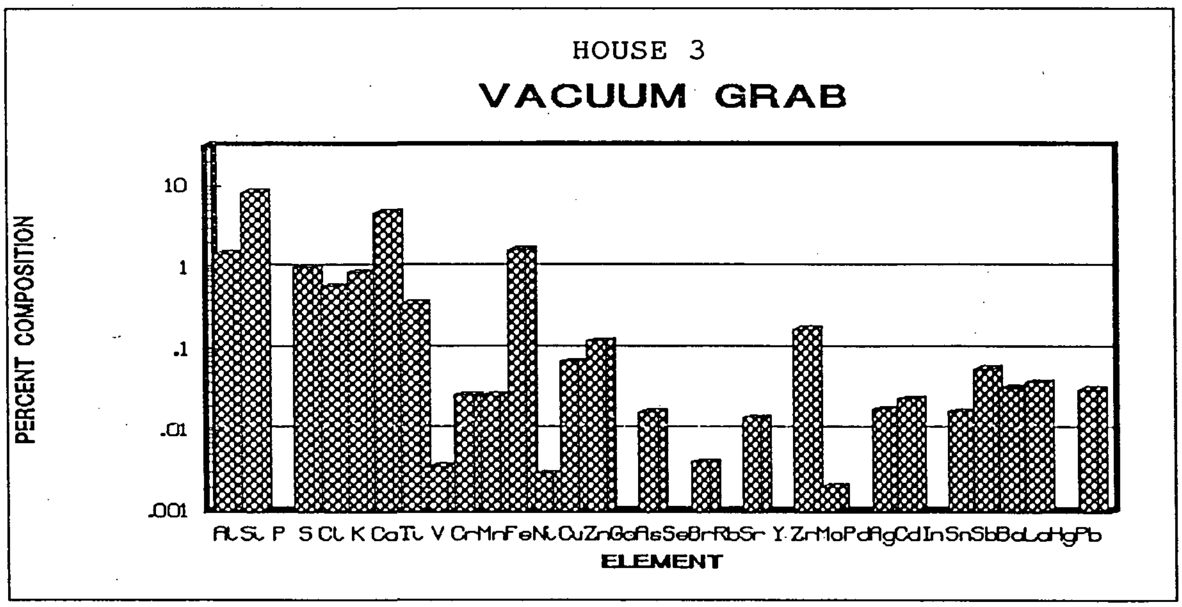


Figure 4.7 Relative Percent Composition of Elements in the Household Vacuum Grab Samples at House 3

Note the strong similarity between the chemical "fingerprint" of the slag in all three driveways with the dust collected in the EPA vacuum at House 2 (See Figures 4.2 through 4.5). The dust collected in the homeowner's vacuum contains a wider variety of chemical constituents (see Figures 4.6 and 4.7). More calcium was apparent in the homeowner's vacuum, and sulfur and chlorine were prominent in the household vacuum and absent in the EPA vacuum catch. It is likely that household vacuums catch more hair and skin from people and pets than the EPA vacuum. Animal and human hair and skin could account for calcium, sulfur and chlorine. Fireplace ash is another possible source of the chemical elements in the household vacuum. (All the houses had animals and fireplaces.) There are several other interesting trace metals in the household vacuum catch, such as zirconium, vanadium, manganese and bromine, that did not show up in the EPA vacuum catch.

One approach to comparison of chemical fingerprints is to examine ratios of arsenic and lead to indicator elements. Silicon is abundant in soils, and titanium is a somewhat constant trace constituent in soils. table 4.3 shows ratios in the chemical composition of slag and vacuum dust analyzed by XRF. Only the EPA vacuum sample collected in House 2 was similar to chemicals and chemical ratios in the slag in the driveway or to slag collected previously in the slag piles at the old ASARCO smelter.

Table 4.3

PERCENT ELEMENTAL COMPOSITION OF SLAG SAMPLES

	SLAG COARSE	SLAG FINE	DR SL1	DR SL2	DR SL3	HVS3	H VAC 2	H VAC 3
SI	14.1	15.8	12.6	12.0	18.2	12.6	5.5	8.4
TI	.3	.2	.3	.2	.3	.3	.3	.4
AS	1.9	2.5	1.7	4.6	1.7	1.6	> .1	> .1
PB	.9	1.3	1.0	1.2	1.1	.9	.1	> .1
SI/AS	7.5	6.3	7.4	2.6	11.0	8.0	163.9	503.9
SI/PB	15.8	12.3	12.7	10.3	16.4	13.9	108.3	262.2
TI/AS	.2	.1	.2	.1	.2	.2	9.7	21.4
TI/PB	.3	.2	.3	.2	.3	.3	6.4	11.1

SLAG COARSE = SOURCE SAMPLE TACOMA SMELTER COARSE (LESS 10μg) FRACTION
SLAG FINE = SOURCE SAMPLE TACOMA SMELTER FINE (LESS THAN 2.5 μg) FRACTION
AEROSOLIZED MATERIAL PASSING THROUGH 400 MESH SIEVE (LESS THAN 38μg)
DR SL1 = HOUSE 1, TACOMA
DR SL2 = HOUSE 2, GIG HARBOR
DR SL3 = HOUSE 3, TACOMA
HVS3 = EPA VAC HOUSE 2, GIG HARBOR
H VAC2 = HOUSE VAC HOUSE 2, GIG HARBOR
H VAC3 = HOUSE VAC HOUSE 2, GIG HARBOR

4.3 CMB Analysis of XRF Results

Chemical mass balance (CMB) models are useful tools for source apportionment of pollution sources and analysis of the chemical composition of the ambient air. They can also be used to relate the chemical composition of slag to house dust chemical composition. CMB analysis was applied to the XRF data collected in the driveways and in the household and EPA HVS3 catches. The individual results of this analysis are presented in Appendix B of this report. The driveway slag was modeled as a contributing source of lead, arsenic, sulfur, silicon, aluminum, calcium, and iron. Those same elements, along with their source inventory identification, are listed below:

- Tacoma road dust (TACRD)
- Tacoma soil (TACSD)
- Tacoma motor vehicle composite (TACMV)
- Tacoma leaded vehicles (TACPB)
- Kraft recovery mill (KRAFT)
- Tacoma wood combustion (TACWD)

Typically the CMB model is run in an iterative manner. Here indoor carpet dusts were modeled by trying single source profiles and combinations of source profiles such as driveway slag, road dust and wood combustion to determine the sources of the indoor dusts.

We found an almost perfect modeled fit using 13 chemicals in the dust collected using the HVS3 at House 2. Using only the House 2 driveway slag profile, the model explained 99.7% of the mass in the household dust (see Table 4.4). It is interesting that we were not able to fit combinations of the above sources, either from the driveway or our Tacoma source profile library, to either of the homeowners' vacuum dust samples. In fact, less than 40% of the mass in the household vacuums could be explained using the library of Tacoma sources or the current driveway slag.

4.4 Floor and Refrigerator Wipes

Tables 4.5 and 4.6 present the results obtained from refrigerator and floor wipe samples. The most noticeable difference was at House 3 for the refrigerator wipes. Unlike the other two houses, the surface sampled was a freezer in the ground level garage. Ground level sampling was consistently done at all homes; at House 3 the refrigerator was upstairs. Carpeted stairways form limiting barriers to tracked-in dust. Because of the stairs to the refrigerator in House 3, the freezer at ground level was used instead. The high concentrations of arsenic and lead on the top of the freezer in House 3 was duplicated in the sample duplicate on the same freezer. The higher concentration for sample 3 is likely due to its closer proximity to car exhaust and driveway dusts. The floor wipes in all cases had lower concentrations of both lead and arsenic.

Table 4.4

SOURCE CONTRIBUTION ESTIMATES (SCEs) FOR THE PARTICULATE LESS THAN 38 MICRONS IN THE HVS3 SAMPLE AT HOUSE 2 IN GIG HARBOR

SOURCE CONTRIBUTION ESTIMATES - SITE: EPAVAC DATE: VERSION: 7.0
SAMPLE DURATION START HOUR SIZE: FINE
R SQUARE 1.00 PERCENT MASS 99.7
CHI SQUARE .12 DF 12

SOURCE *	TYPE	SCE(UG/M3)	STD ERR	TSTAT
12	HTSLAG	.9970	.0512	19.4814

MEASURED CONCENTRATION FINE/COARSE/TOTAL:
1.0+- .1/ .0+- .0/ 1.0+- .1

UNCERTAINTY/SIMILARITY CLUSTERS VERSION: 7.0 SUM OF CLUSTER SOURCES

SPECIES CONCENTRATIONS - SITE: EPAVAC DATE: VERSION: 7.0
SAMPLE DURATION START HOUR SIZE: FINE
R SQUARE 1.00 PERCENT MASS 99.7
CHI SQUARE .12 DF 12

SPECIES		I	MEAS		CALC		RATIO C/M**		RATIO R/U
1	TOT	T	1.00000+-	.10000	.99704+-	.05118	1.00+-	.11	-.0
13	AL	*	.01969+-	.00277	.01970+-	.00277	1.00+-	.20	.0
14	SI	*	.12620+-	.01678	.12603+-	.01674	1.00+-	.19	.0
15	P		.00000<	.00007	.00000<	.00006	.00<	.00	.0
16	S	*	.00000<	.00139	.00000<	.00159	.00<	.00	.0
17	CL	*	.00000<	.00021	.00000<	.00023	.00<	.00	.0
19	K	*	.00419+-	.00048	.00387+-	.00044	.92+-	.15	-.5
20	CA	*	.02479+-	.00280	.02262+-	.00254	.91+-	.15	-.6
22	TI	*	.00279+-	.00028	.00266+-	.00027	.95+-	.13	-.3
23	V		.00000<	.00004	.00000<	.00003	.00<	.00	.0
24	CR		.00065+-	.00007	.00070+-	.00007	1.09+-	.15	.6
25	MN	*	.00000<	.00003	.00000<	.00002	.00<	.00	.0
26	FE	*	.17130+-	.01713	.16860+-	.01686	.98+-	.14	-.1
28	NI		.00000<	.00003	.00000<	.00002	.00<	.00	.0
29	CU		.01784+-	.00178	.01826+-	.00183	1.02+-	.14	.2
30	ZN	*	.00608+-	.00061	.00601+-	.00060	.99+-	.14	-.1
31	GA		.00000<	.00003	.00000<	.00003	.00<	.00	.0
33	AS	*	.01581+-	.00158	.01705+-	.00170	1.08+-	.15	.5
34	SE		.00000<	.00002	.00000<	.00001	.00<	.00	.0
35	BR	*	.00000<	.00006	.00000<	.00006	.00<	.00	.0
37	RB		.00000<	.00002	.00000<	.00001	.00<	.00	.0
38	SR		.00009+-	.00002	.00012+-	.00001	1.31+-	.31	1.2
39	Y		.00000<	.00002	.00000<	.00002	.00<	.00	.0
40	ZR		.00000<	.00003	.00000<	.00003	.00<	.00	.0
42	MO		.00143+-	.00014	.00139+-	.00014	.97+-	.14	-.2
46	PD		.00000<	.00013	.00003<	.00012	.00<	.00	.1
47	AG		.00000<	.00016	.00000<	.00015	.00<	.00	.0
48	CD		.00004<	.00017	.00031<	.00016	8.19<	36.65	1.2
49	IN		.00000<	.00017	.00000<	.00016	.00<	.00	.0
50	SN		.00010<	.00019	.00049<	.00018	4.71<	8.72	1.5
51	SB		.00305+-	.00030	.00342+-	.00034	1.12+-	.16	.8
56	BA		.00100+-	.00068	.00000+-	.00063	.00+-	.63	-1.1
57	LA		.00137+-	.00093	.00111+-	.00085	.81+-	.83	-.2
80	HG		.00000<	.00004	.00000<	.00003	.00<	.00	.0
82	PB	*	.00906+-	.00091	.00992+-	.00099	1.09+-	.15	.6

*fitting species
**calculated/measured

Table 4.5
REFRIGERATOR WIPE SAMPLES

HOUSE	ARSENIC ng/cm^2	LEAD ng/cm^2
1	1.8	30
2	3.2	7.8
3	580	580
3D	390	360

Table 4.6
FLOOR WIPE SAMPLES

HOUSE	ARSENIC ng/cm^2	LEAD ng/cm^2
1	.21	.8
2	.76	1.3
2D	.97	1.6
3	1.5	1.6

4.5 Analysis of Driveway Slag

The results in Table 4.7 show that both arsenic and lead concentrations increase with decreasing particle size in all three driveways. House 2 slag at Gig Harbor, which was farthest from the smelter, had the highest concentrations of lead and arsenic. House 2 also had the least weathered looking slag and possibly the least used driveway.

Table 4.7
DRIVEWAY SLAG

HOUSE	ARSENIC ($\mu g/g$)				LEAD ($\mu g/g$)			
SIZE FRACTION(μm)	>180	>75	>38	<38	>180	>75	>38	<38
1	2600	4200	6000	7000	1700	2300	3500	4200
2	5000	13000	11000	19000	2600	4300	2900	4900
3	2500	4200	6000	7100	1700	2700	4100	4600

4.6 Analysis of Yard Soil

The concentrations of arsenic and lead in the yard soil is presented in Table 4.8. The samples are labeled A, B, C, and D to represent the assumed slag exposure regimes sampled where:

A) indicates most likely part of the driveway from which slag could be tracked or leached onto the yard;

B) indicates a location on a diagonal line from the driveway to a house entrance, no more than two feet from the driveway;

C) indicates a location on a diagonal line from the driveway to the house or perpendicular to the driveway and no less than 18 feet from the driveway; and

D) indicates a sheltered location on a diagonal line perpendicular to the end or side of the driveway and no less than 18 feet from the driveway.

At House 1, the lowest concentrations were found in a part of the yard that was a former garden. The highest concentrations of lead and arsenic were found in the location most removed from the slag driveway at House 1. Possibly paint from a nearby fence, drip line of the tree above, or some other contaminated source may have caused these high concentrations.

Yard soil at House 2 had the lowest levels of lead and arsenic. Grass in the yard at House 2 was luxuriant and had a deep sod layer. All four exposure regimes had similar lead and arsenic levels, but the concentration levels were lower in the less exposed locations (farthest from the driveway) than we expected.

Table 4.8

YARD SOIL

HOUSE	ARSENIC ($\mu g/g$)				LEAD ($\mu g/g$)			
SIZE FRACTION (μm)	>180	>75	>38	<38	>180	>75	>38	<38
1A	120	57	80	110	220	100	120	140
1B	120	120	150	200	230	210	210	200
1C	17	33	48	73	30	67	95	93
1D	120	100*	150	180	420	310*	460	450
2A	15	22	25	84	45	60	75	31
2B	22	21	38*	27	47	48	91*	61
2C	16	18	23	29	30	32	43	53
2D	8.3	12	17	19	13	23	51	49
3A	60	55	490*	180*	69	65	67*	71*
3A dup	60	63	170*	62*	70	45	64*	100*
3B	63	49	150	100	87	48	43	54
3C	61	39	47	61	66	42	46	71
3D	50	42	81*	68*	55	55	630*	2300*

*Small sample mass

Several of the numbers in Table 4.8 are marked with an asterisk. These are estimated values. The actual concentrations of arsenic and lead in these samples are uncertain because the small amount of sample available after sieving made the chemical analysis difficult.

These sample results can be compared to the background levels of arsenic and lead in urban areas which are about 20 ppm and 250 ppm, respectively. Becasue the locations sampled in this study are somewhat isolated from the typical urban environment, the background arsenic and lead in these soils might be expected to be lower than this. Also, it should be kept in mind that these background measurements were made on soils that were not separated into smaller size fractions and represent an average of all of the arsenic and lead concentrations in all the particle sizes.

House 2 has the lowest levels for both lead and arsenic; a few of the arsenic in soil levels ar elevated above background. At House 1, most of the arsenic and a few of the lead samples are above background. House 3 has the highest levels of lead and arsenic. However, the values for lead that are above background in House 3 are estimated values.

4.7 Analysis of Vacuum Dust

The concentrations of arsenic and lead in the dust collected in the homeowner's vacuum cleaner were lower than those found in the yard soil except for House 2 (see Table 4.9). Lead concentrations for House 2 are two to four times higher indoors than in the yard soil. Highest concentrations of both arsenic and lead were clearly found in the smallest size fractions. This was noted in both household vacuum and EPA HVS3 vacuum catches (see Table 4.10).

Table 4.9

HOUSE VACUUM

HOUSE	ARSENIC (μg/g)				LEAD (μg/g)			
SIZE FRACTION (μm)	>180	>75	>38	<38	>180	>75	>38	<38
1	50	55	70	ISF	85	140	180	ISF
2	75	69	110	170	180	120	150	200
3	24	86	110	ISF	33	40	61	ISF

ISF = insufficient sample

The highest concentrations of lead and arsenic were found in the EPA vacuum catches on the entry mat at House 2 and in the garage at House 3. The concentration per unit area is also presented in Table 4.10. The largest concentration tended to be in the smallest size fraction. In the House 2 entry mat, the greater than 38 µm size range had higher arsenic than lead concentrations, reflecting the arsenic-to-lead ratios in slag.

4.8 Analysis of Ground Slag Samples

Table 4.11 presents a comparison of the effect of grinding on measured concentration of lead and arsenic. Aliquots from the size fraction (>180 μm) were ground to a fine powder (<38 μm). The measured concentrations in the ground sample of both arsenic and lead were nearly twice as high as in the original sample. The results suggest that when large particles in the driveway are ground up and pulverized by traffic, the availability of lead and arsenic increases significantly.

Table 4.10
EPA VACUUM RESULTS

HOUSE	SURFACE	ARSENIC								LEAD							
		SIZE FRACTION (μm)								SIZE FRACTION (μm)							
		>180		>75		>38		<38		>180		>75		>38		<38	
		μg/g	μg/cm²	μg/g	μg/cm²	μg/g	μg/cm²	μg/g	μg/cm²	μg/g	μg/cm²	μg/g	μg/cm²	μg/g	μg/cm²	μg/g	μg/cm²
1	CARPET	95	<.01	49	<.01	180	<.01	120	<.01	230	.01	170	<.01	72	<.01	270	<.01
2	CARPET	180	.01	140	.02	230	.12	360	.17	110	.01	190	.03	250	.13	250	.12
2	MAT	520	.07	290	.01	460	.23	690	.47	240	.03	150	<.01	210	.10	290	.20
3	ENTRY*	300	.03	580	<.01	250	.03	300	.01	160	.02	500	<.01	220	.03	280	.01
3	CARPET	150	<.01	95	<.01	190	<.01	380	<.01	130	<.01	130	<.01	270	.01	500	<.01
3	GARAGE	240	.02	ISS	<.01	180	<.01	390	.02	190	<.01	ISS	<.01	230	.01	400	<.01

The calculation of concentration per unit area is presented in Appendix A.
*Carpet was less than six months old.

Table 4.11

COMPARISON OF CONCENTRATIONS IN GROUND AND UNGROUND STATE

Driveway Location	Before Grinding As $\mu g/g$	Before Grinding Pb $\mu g/g$	After Grinding As $\mu g/g$	After Grinding Pb $\mu g/g$
House 1	2600	1700	5000	3300
House 2	5000	2600	11000	4100
House 3	2500	1700	4300	3200

4.9 Method Validation and Quality Control

4.9.1 Analysis of Field Duplicates

Duplicate samples were collected to determine the representativeness of the sampling locations. Table 4.12 shows a comparison of duplicate sample collected on refrigerators, floors, and at one yard sampling location. A large difference is notable on the refrigerator (freezer) wipe at House 3. The concentrations in both the sample and duplicate sample are about 100 times larger than the wipes of refrigerators at Houses 1 and 2. The difference between the sample and the duplicate is about a 50% difference, and is probably related to proximity to sources of the two locations. The largest concentrations were on the side of the freezer nearest to the car and driveway. This also may have been due to other exposure differences across the top of the freezer.

The floor wipes at House 2 show good agreement between sample and duplicate of measured concentrations of lead and arsenic.

The yard soil duplicate comparison also suggests that the sampling techniques provide representative results when a large enough sample is available. Larger differences between samples and duplicate samples were noted in the two smallest size fractions.

Table 4.12

COMPARISON OF LEAD AND ARSENIC CONCENTRATIONS
MEASURED BY DUPLICATE SAMPLES

LOCATION	REFRIGERATOR WIPES	
	As $\mu g/cm^2$	Pb $\mu g/cm^2$
House 3	580	580
Duplicate	390	360
RPD	39.2	46.8
	FLOOR WIPE	
House 2	0.76	1.3
Duplicate	0.97	1.6
RPD	24.3	20.7
	YARD SOIL	
	As $\mu g/g$	Pb $\mu g/g$
House 3 (>180 μm)	60	69
Duplicate	60	70
RPD	0	1.4
House 3 (>75 μm)	55	65
Duplicate	63	45
RPD	13.6	36.3
House 3 (>38 μm)	490*	67*
Duplicate	170*	64*
RPD	145.4	4.6
House 3 (38 μm)	180*	71*
Duplicate	62*	100*
RPD	97.5	10.4

* Small simple size (< 0.3 grams)
RPD = Relative percent difference

Table 4.13 presents results for blanks and rinses collected in this field study. The rinses in all but EPA vacuum rinses were the final distilled water rinse after the equipment was thoroughly cleaned. These rinses were used as a field blank. However, the rinse of EPA vacuum were acetone-pentane rinses to collect particles remaining in the vacuum and catch bottle, and thus are not really a blank, but rather the remainder of the vacuum catch. These numbers should not be subtracted from the concentrations in the HVS3 catch, but could be added to those numbers. They were not added to catch in the HVS3.

4.9.2 Quality Assurance/Quality Control

The quality assurance/quality control (QA/QC) program for the Tacoma Slag study included the following QC elements:

- Blanks, calibration standards, and calibration check standards
- Laboratory duplicates
- Predigestion matrix spikes
- Postdigestion analytical spikes
- Blind standard reference materials (SRMs) sent from the field.

The satisfactory analysis of blanks, calibration standards, and calibration check standards is part of and precedes the analysis of any samples. Instruments are considered calibrated and ready for analysis if the correlation coefficient of the calibration curve is at least 0.995, and if the recovery of the calibration check standard is within the range of 90–110%.

Table 4.13

BLANK AND RINSE ANALYSIS

FLOOR AND REFRIGERATOR BLANKS		
	Field Blank	Trip Blank
As	< 0.00 mg/cm^2	< 0.00 ng/cm^2
Pb	0.16 ng/cm^2	0.16 ng/cm^2
SOIL SAMPLE BUCKET TRIP BLANK		
As	1.6 μg	
Pb	4.9 μg	
SOIL CORER RINSE AFTER HOUSE 1		
As	0.05 μg	
Pb	0.14 μg	
SPATULA RINSE AFTER HOUSE 2		
As	0.76 μg	
Pb	0.1 μg	
SOIL CORER RINSE AFTER HOUSE 2		
As	< .05 μg	
Pb	< .01 μg	
SOIL CORER RINSE AFTER HOUSE 3		
As	< .05 μg	
Pb	< .01 μg	
SPATULA RINSE AFTER HOUSE 3		
As	0.24 μg	
Pb	0.27 μg	
SHOVE/RINSE BETWEEN DRIVEWAY 2 AND 3		
As	1.6 μg	
Pb	1.2 μg	

Table 4.13

(Continued)

HOUSE 1 EPA VACUUM RINSE AFTER RUG SAMPLE COLLECTION	
As	7.5 μg
Pb	20 μg
HOUSE 2 EPA VACUUM RINSE AFTER RUG SAMPLE COLLECTION	
As	60 μg
Pb	35 μg
HOUSE 2 EPA VACUUM RINSE AFTER FLOOR MAT SAMPLE COLLECTION	
As	120 μg
Pb	50 μg
HOUSE 3 EPA VACUUM RINSE AFTER ENTRY SAMPLE	
As	45 μg
Pb	38 μg
HOUSE 3 EPA VACUUM RINSE AFTER FAMILY RM SAMPLE COLLECTION	
As	55 μg
Pb	70 μg
HOUSE 3 EPA VACUUM RINSE AFTER CARPORT	
As	26 μg
Pb	32 μg

Duplicates provide a means for estimating precision. The duplicates are created by splitting a given sample before any sample preparation procedures are begun. The precision QC statistic is the relative percent difference (RPD), defined in Section 3. The results of the analysis of duplicates are summarized in Table 4.14. For aqueous samples, the EPA considers ±20% RPD to be an acceptable precision. For soils, the EPA uses this same value as a target precision, but considers acceptable RPDs up to ±35%. All of the RPDs listed in Table 4.14 are well within these guidelines.

Table 4.14

RESULTS OF THE ANALYSIS OF LABORATORY DUPLICATES

Sample Matrix	No. of Duplicates	RPD or AVG. RPD (%) Arsenic	Lead
Water Rinse	1 As/1 Pb	1.2	0
Water/Acetone Rinse	2 As/2 Pb	3.2	2.4
Wipe	2 As/3 Pb	4.8	1.4
Soil (ICP)	11 As/14 Pb	3.1 ± 2.7	2.8 ± 2.5
Soil (GFAA)	10 As/6 Pb	2.1 ± 1.9	0.9 ± 0.8

Accuracy of the laboratory results can be estimated by the analysis of pre- and post-digestion spikes. The pre-digestion spikes are created by splitting a given sample before sample preparation and adding known amounts of pure element standards to one of the sample splits. The post-digestion spikes are created by adding known amounts of pure element standards to a sample digestate after the sample has been analyzed. The QC statistic is the percent recovery (%R). The results of the analysis of both types of spikes are summarized in Table 4.15. For aqueous samples and soils, the EPA considers an acceptable spike recovery range to be 75-125%. All of the percent recoveries using EPA Method 3050 digestion listed in Table 4.15 are well within these guidelines.

Table 4.15

RESULTS OF THE ANALYSIS OF SPIKED SAMPLES

Sample Matrix	Spike	No. of Spikes	% Recovery or Avg. % Recovery Arsenic	Lead
Water Rinse	Pre	2 As/2 Pb	99.5	105.5
	Post	1 As/1 Pb	101	96
Water/Acetone Rinse	Post	2 As/2 Pb	86.4	97
Wipe	Post	2 As/2 Pb	90	102
Soil (ICP)	Pre	5 As/5 Pb	97.8	95.6
	Post	11 As/11 Pb	96.6	95.0
Soil (GFAA)	Pre	2 As/1 Pb	94	108
	Post	2 As/2 Pb	88.4	96.0

A further check of accuracy is the analysis of sample reference materials (SRMs) sent blind from the field. The results of the analysis of blind solid SRMs are summarized in Table 4.16. There are no EPA guidelines for the percent recovery of field solid SRMs, because agency-approved digestions are strong-acid extractions designed to extract metals that are bio-available. SRMs are certified for total metals only. Thus, the results obtained via EPA digestions can vary considerably from the certified values, most often (but not always) being lower. All of the arsenic recoveries and two of the lead recoveries were within 69–92%. Two of the lead recoveries were low. Considering the excellent spike recoveries discussed above, it is unlikely that the poor SRM recoveries were due to analytical error. Most likely, the low recoveries are due to a combination of the poor digestion efficiency of the method and unavoidable matrix effects.

Table 4.16

STANDARD REFERENCE MATERIALS ANALYSIS RESULTS

SRM	Arsenic			Lead		
	Result	Given	%R	Result	Given	%R
CBS CCN-1	240	260 ± 20	92.3	27,000	74,500 ± 500	36.2
CBS SO-2	0.83	1.2 ± 0.2	69.2	5.4	21 ± 4	25.7
CBS PO-1	7000	7700 ± 300	90.9	23,000	27,500 ± 200	83.6
NBS 1648	83	115 ± 10	72.2	5,400	6,550 ± 80	82.4

CBS = Canadian Bureau of Standards
NBS = National Bureau of Standards

5.0 CONCLUSIONS AND RECOMMENDATIONS

This study was designed to sample dust, soil and slag at three selected homes in Tacoma and Gig Harbor, Washington. These homes have driveways surfaced with slag from the ASARCO copper smelter in Ruston. The slag contains arsenic and lead at concentrations greater than 2500 and 1500 ppm respectively. Residences more than four miles from the smelter with slag-covered driveways were selected to investigate the possibility that driveway slag was the major source of arsenic and lead at outdoor and indoor locations at each of these residences. We know that baseline levels of arsenic and lead exist in urban areas. It was postulated that residences closer to the smelter would have notable buildups of chemicals from the historical smelter emissions and thus would deviate from our study model, which calls for one source and several recipient areas of arsenic and lead particulates.

Dusts and soil particles from outdoors (soil and driveway dusts) were compared to indoor dusts, using a chemical mass balance (fingerprinting) technique. Four particle size fractions were analyzed, where samples were sufficient, to investigate arsenic and lead concentrations as a function of particle size. Furthermore, particles smaller than 150 microns were analyzed chemically because they can adhere to the hands of children. Indoor samples were taken from kitchen floors, living room carpets, and tops of refrigerators to assess current to long-term buildups of arsenic and lead at the selected homes.

The sampling strategy was designed to measure arsenic and lead levels in driveway slag material and at locations close to slag-covered driveway surfaces, as well as away from the driveways, in order to assess migrations of arsenic and lead from the driveway source area. Soil samples close to the driveway and far from it, as well as from indoor mats and carpets, were taken to investigate track-in concepts.

The conclusions for the study follow:

- There was a very strong correlation between lead and arsenic in driveway slag and in household carpet dusts at one residence. Unfortunately, sufficient carpet dusts for chemical fingerprinting were collected at only one residence -- a special EPA vacuum device for carpets obtained smaller samples than was planned. Chemical mass balance analyses of source (slag) and receptor (carpet) dust at this house showed that 99% of the arsenic and lead concentrations in the dust came from one source: slag from the driveway.

- Concentrations of arsenic and lead were 10 to 20 times greater in driveway slag than in the household carpet dusts. Concentrations in the carpet dusts collected by the EPA sampler varied from 49 to 690 ppm for arsenic and from 72 to 500 ppm for lead. Some of these concentrations in dust are much higher than would be expected given the arsenic and lead levels in urban background soils (20 ppm for arsenic and 250 ppm for lead).

- The highest concentrations for both lead and arsenic were found on entry mats and in a carport. Concentrations of these chemicals in entry mats were often more than twice the interior living room carpet dust levels. This suggests that entry mats are moderately effective as interceptors of tracked-in slag and soil dusts. This also restates the obvious, that the bulk of tracked-in outdoor dusts are located at residential entrances.

- Dust removed from each homeowner's vacuum cleaner resulted in considerable dust, dirt and debris as a result of the general usage of the device in the home and possibly the car and garage. It was, however, found that the special EPA vacuum cleaner was a superior dust collection device for this study because only known carpeted areas were sampled and household debris was not collected.

- The EPA vacuum device was configured to sample only the dust near the carpet surface and not the deep-seated dusts tracked in from prior years. It can thus be concluded that results from this study report conclusions for current residential dust conditions.

- Indoor dust samples were collected from the tops of refrigerators or a freezer and from kitchen floor linoleum at each home. Arsenic and lead concentrations present in these samples indicate the presence of a source or sources for lead and arsenic in the area. However, because of the small amounts of collected dusts, it was not possible to compare these samples to driveway slag materials using the source fingerprinting methods to quantitate source ratios.

- Concentrations of lead and arsenic in the yard soil varied from below local urban background levels (about 20 ppm for arsenic and 250 ppm for lead) to well above these levels.

- Driveway surface materials ranged in size from about one-half inch to about three inches. However, below the surface layer of slag, smaller dust-sized materials were found at each residence. Under vehicular and foot traffic, the grinding of surface chunks of slag and the compression of smaller particles below the surface may be the means by which slag dusts continue to be available for track-in to the homes and across the yards.

- For slag materials and carpet dusts where sufficient material was collected, clearly higher arsenic and lead concentrations were observed with the smaller particle sizes. The extent of this apparent enrichment was greatest for slag where the smallest particulate concentrations (less than 38 microns) ranged to 19,000 ppm for arsenic and 4,900 ppm for lead. Enrichment for the same smallest particles in carpet dusts ranged up to 690 ppm for arsenic and

500 ppm for lead. In yard soil, there was less enrichment in the smallest particulate sizes.

- The largest size fractions (< 180 microns) dealt with in this study from the slag and carpet dusts were consistently greater than background arsenic levels.

- The study found a factor of two increase in the concentrations of arsenic and lead by grinding and pulverizing 180 micron or greater-sized particles to a diameter less than 38 microns. These results may be due to an increased availability of arsenic and lead in these samples as a result of increased surface area and enhanced chemical digestibility in the laboratory. An additional explanation is that once the surface (oxide) coating on slag is broken, additional chemicals may then be released.

After review of the data and procedures used to collect information, we have several recommendations for future studies:

- The amount of driveway slag collected was more than adequate. One 5-gallon bucket per driveway will be adequate for future sampling, rather than collecting two buckets as collected for this study. Screening out slag chunks in the field will also save time in the future.

- A composite surface soil sample from each yard would be needed for future studies if fingerprinting studies are designed to include source contributions from yard soil materials.

- The EPA vacuum (HVS3) can collect dust particles smaller than 150 microns without collecting household debris. It is thus a necessary field sampling device for studies of this type. However, larger surface areas need to be sampled to obtain sufficient sample amounts for laboratory analysis.

- To explain the sources of dust in the homeowner's vacuum cleaner using receptor modeling, several additional source profiles would be needed. These include household chemicals such as carpet cleaners and deodorants, furnace dusts and possible discarded dermal material. Outside source profiles would include yard soils, as noted above, and street and road dusts.

- It would be valuable to sample a baseline control home without a slag-surfaced driveway in the Tacoma-Ruston and Gig Harbor areas, as well as a background level control home which is away from any smelter influence. Such controls would allow comparison of study results to those obtained for control homes.

6.0 BIBLIOGRAPHY AND REFERENCES

Barley, G., 1981: "Air Quality and Respiratory Health: A Comparison Study of Two Health Contaminants," Masters Thesis, University of Washington, Seattle.

Black and Veatch, 1988: "Endangerment Assessment, Ruston/Vashon Island, Technical Memorandum", State of Washington Department of Ecology, Olympia, Washington.

Bowen, H.J.M., 1966: Trace Elements in Biochemistry, Academic Press, New York, 241 pp.

Cooper, J.A., et al., 1984: "Applications of Receptor Modeling Methods to Source Apportionment of Arsenic in the Ruston-Tacoma, Washington Airshed: A Feasibility Study," NEA, Inc., Beaverton, Oregon, 59 pp.

Davidson, C.L. and Elias, R.W., 1986: "Environmental concentrations and potential pathways to human exposure," in Air Quality Criteria for Lead, U.S. EPA, Research Triangle Park.

Davies, D.J.A, et al., 1990: "Relationships between blood lead and lead intake in two-year-old urban children in the U.K.," Science of the Total Environment, 90, p. 13-29.

National Academy of Sciences, 1977: Arsenic, National Academy of Sciences Publication, Washington, DC, 332 pp.

Ibid., 1972: Lead: Biological Effects of Atmospheric Pollutants, National Academy of Sciences Publication, Washington, DC, 330 pp.

Roberts, J.W., 1991: Personal Communication.

Roberts, J.W., et al., 1991: "Reducing lead exposure from remodeling and soil track-in in older homes," Proceedings of Air & Waste Management Association Annual Meeting, Vancouver, B.C. In press.

Ibid., 1990: "Development and testing of a high volume sampler for pesticides and toxics in dust," Toxicology and Industrial Health, 8, .1

Ibid., 1990: "Monitoring and controlling lead in house dust in older homes," in Vol. 2: Indoor Air '90: Proc. 5th International Conf. on Indoor Air and Climate, pp. 425-430, Canada Mortgage and Housing Corp., Ottawa.

APPENDIX A

LABORATORY ANALYSIS REPORT
(TABLE A.1)

QUALITY ASSURANCE REPORT
(TABLE A.2)

CALCULATION
(TABLE A.3)

Table A.1

Client Name: Tacoma Slag Study
Date Received: 1/ 4/91

Report Date: 1/18/91
Project Number: 316/001

NEA ID: 91-S1 Client ID: TS 1127904-C

Sample Mass: 0.4993 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	70	ug/gram	1/18/91
Pb	180	ug/gram	1/18/91

NEA ID: 91-S2 Client ID: TS 1127939-D

Sample Mass: 0.4959 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	66	ug/gram	1/18/91
Pb	110	ug/gram	1/18/91

NEA ID: 91-S3 Client ID: TS 1127906-7-A

Sample Mass: 0.5004 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	2600	ug/gram	1/18/91
Pb	1700	ug/gram	1/18/91

NEA ID: 91-S4 Client ID: TS 1127906-7-AG

Sample Mass: 0.4992 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	4200	ug/gram	1/18/91
Pb	2300	ug/gram	1/18/91

NEA ID: 91-S5 Client ID: TS 1127906-7-C

Sample Mass: 0.5029 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	6000	ug/gram	1/18/91
Pb	3500	ug/gram	1/18/91

Table A.1

Client Name: Tacoma Slag Study
Date Received: 1/04/91

Report Date: 1/18/91
Project Number: 316/001

NEA ID: 91-S6 Client ID: TS 1127906-7-D

Sample Mass: 0.4996 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	7000	ug/gram	1/18/91
Pb	4200	ug/gram	1/18/91

NEA ID: 91-S7 Client ID: TS 1127950-1-A

Sample Mass: 0.4959 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	5000	ug/gram	1/18/91
Pb	2600	ug/gram	1/18/91

NEA ID: 91-S8 Client ID: TS 1127950-1-AG

Sample Mass: 0.3941 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	11000	ug/gram	1/18/91
Pb	4100	ug/gram	1/18/91

NEA ID: 91-S9 Client ID: TS 1127950-1-B

Sample Mass: 0.4961 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	13000	ug/gram	1/18/91
Pb	4300	ug/gram	1/18/91

NEA ID: 91-S10 Client ID: TS 1127950-1-C

Sample Mass: 0.4929 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	11000	ug/gram	1/18/91
Pb	2900	ug/gram	1/18/91

Table A.1

Client Name: Tacoma Slag Study
Date Received: 1/04/91

Report Date: 1/18/91
Project Number: 316/001

NEA ID: 91-S11 Client ID: TS 1127953-4-A

Sample Mass: 0.4956 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	2500	ug/gram	1/18/91
Pb	1700	ug/gram	1/18/91

NEA ID: 91-S12 Client ID: TS 1127953-4-AG

Sample Mass: 0.5006 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	4300	ug/gram	1/18/91
Pb	3200	ug/gram	1/18/91

NEA ID: 91-S13 Client ID: TS 1127953-4-B

Sample Mass: 0.4926 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	4200	ug/gram	1/18/91
Pb	2700	ug/gram	1/18/91

NEA ID: 91-S14 Client ID: TS 1127953-4-C

Sample Mass: 0.4987 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	6000	ug/gram	1/18/91
Pb	4100	ug/gram	1/18/91

NEA ID: 91-S15 Client ID: TS 1127906-7-AG

Sample Mass: 0.4974 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	5000	ug/gram	1/18/91
Pb	3300	ug/gram	1/18/91

Table A.1

Client Name:	Tacoma Slag Study	Report Date:	1/18/91
Date Received:	01/04/91	Project Number:	316/001

NEA ID: 91-S16 Client ID: TS 1127950-1-D

Sample Mass: 0.4936 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	19000	ug/gram	1/18/91
Pb	4900	ug/gram	1/18/91

NEA ID: 91-S17 Client ID: TS 1127953-4-D

Sample Mass: 0.4962 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	7100	ug/gram	1/18/91
Pb	4600	ug/gram	1/18/91

Table A.1

Client Name: Tacoma Slag Study	Report Date: 1/18/91
Date Received:	Project Number: 316/001

NEA ID: 90-S22 Client ID: TS 1127901

Sample Area: 645 cm2 Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	1.8	ng/cm2	12/20/90
Pb	30	ng/cm3	12/31/90

NEA ID: 90-S23 Client ID: TS 1127902

Sample Area: 2580 cm2 Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	0.21	ng/cm2	12/20/90
Pb	0.80	ng/cm2	12/31/90

NEA ID: 90-S24 Client ID: TS 1127903-A

Sample Mass: 0.5271 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	95	ug/gram	1/02/91
Pb	230	ug/gram	1/02/91

NEA ID: 90-S25 Client ID: TS 1127903-B

Sample Mass: 0.1428 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	49	ug/gram	1/02/91
Pb	170	ug/gram	1/02/91

NEA ID: 90-S26 Client ID: TS 1127903-C

Sample Mass: 0.2300 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
Pb	180	ug/gram	1/02/91
As	72	ug/gram	1/02/91

Table A.1

Client Name: Tacoma Slag Study
Date Received:

Report Date: 1/18/91
Project Number: 316/001

NEA ID: 90-S27 Client ID: TS 1127903-D

Sample Mass: 0.0289 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	120	ug/gram	1/02/91
Pb	270	ug/gram	1/02/91

NEA ID: 90-S34 Client ID: TS 1127908-A

Sample Mass: 0.4817 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	120	ug/gram	1/09/91
Pb	220	ug/gram	1/09/91

NEA ID: 90-S35 Client ID: TS 1127908-B

Sample Mass: 0.5225 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	57	ug/gram	1/09/91
Pb	100	ug/gram	1/09/91

NEA ID: 90-S36 Client ID: TS 1127908-C

Sample Mass: 0.4980 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	80.	ug/gram	1/09/91
Pb	120	ug/gram	1/09/91

NEA ID: 90-S37 Client ID: TS 1127908-D

Sample Mass: 0.4920 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	110	ug/gram	1/09/91
Pb	140	ug/gram	1/09/91

Table A.1

Client Name: Tacoma Slag Study
Date Received:

Report Date: 01/18/91
Project Number: 316/001

NEA ID: 90-S39 Client ID: TS 1127909-A

Sample Mass: 0.4825 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	120	ug/gram	1/09/91
Pb	230	ug/gram	1/09/91

NEA ID: 90-S40 Client ID: TS 1127909-B

Sample Mass: 0.5407 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	120	ug/gram	1/09/91
Pb	210	ug/gram	1/09/91

NEA ID: 90-S41 Client ID: TS 1127909-C

Sample Mass: 0.5087 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	150	ug/gram	1/09/91
Pb	210	ug/gram	1/09/91

NEA ID: 90-S42 Client ID: TS 1127909-D

Sample Mass: 0.5446 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	200	ug/gram	1/09/91
Pb	200	ug/gram	1/09/91

Table A.1

Client Name: Tacoma Slag Study
Date Received:

Report Date: 1/18/91
Project Number: 316/001

NEA ID: 90-S44 Client ID: TS 1127910-A

Sample Mass: 0.5304 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	17	ug/gram	1/09/91
Pb	30	ug/gram	1/09/91

NEA ID: 90-S45 Client ID: TS 1127910-B

Sample Mass: 0.5221 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	33	ug/gram	1/09/91
Pb	67	ug/gram	1/09/91

NEA ID: 90-S46 Client ID: TS 1127910-C

Sample Mass: 0.5004 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	48	ug/gram	1/09/91
Pb	95	ug/gram	1/09/91

NEA ID: 90-S47 Client ID: TS 1127910-D

Sample Mass: 0.5122 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	73	ug/gram	1/09/91
Pb	93	ug/gram	1/09/91

NEA ID: 90-S49 Client ID: TS 1127911-A

Sample Mass: 0.4983 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	120	ug/gram	1/09/91
Pb	420	ug/gram	1/09/91

Table A.1

Client Name: Tacoma Slag Study
Date Received:

Report Date: 1/18/91
Project Number: 316/001

NEA ID: 90-S50 Client ID: TS 1127911-B

Sample Mass: 0.0450 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	100	ug/gram	1/09/91
Pb	310	ug/gram	1/09/91

NEA ID: 90-S51 Client ID: TS 1127911-C

Sample Mass: 0.5039 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	150	ug/gram	1/09/91
Pb	460	ug/gram	1/09/91

NEA ID: 90-S52 Client ID: TS 1127911-D

Sample Mass: 0.4875 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	180	ug/gram	1/09/91
Pb	450	ug/gram	1/09/91

NEA ID: 90-S54 Client ID: TS 1127013-A

Sample Mass: 0.5154 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	15	ug/gram	1/09/91
Pb	45	ug/gram	1/09/91

NEA ID: 90-S55 Client ID: TS 1127013-B

Sample Mass: 0.4960 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	22	ug/gram	1/09/91
Pb	60	ug/gram	1/09/91

Client Name: Tacoma Slag Study
Date Received:

Report Date: 1/18/91
Project Number: 316/001

NEA ID: 90-S56 Client ID: TS 1127013-C

Sample Mass: 0.5011 grams Extraction Volume: 25.0 mL

Analyte		Result	Date Analyzed
As	25	ug/gram	1/09/91
Pb	75	ug/gram	1/09/91

NEA ID: 90-S57 Client ID: TS 1127013-D

Sample Mass: 0.5030 grams Extraction Volume: 25.0 mL

Analyte		Result	Date Analyzed
Pb	84	ug/gram	1/09/91
As	31	ug/gram	1/09/91

NEA ID: 90-S58 Client ID: TS 1127914-A

Sample Mass: 0.4913 grams Extraction Volume: 25.0 mL

Analyte		Result	Date Analyzed
As	22	ug/gram	1/09/91
Pb	47	ug/gram	1/09/91

NEA ID: 90-S59 Client ID: TS 1127914-B

Sample Mass: 0.5220 grams Extraction Volume: 25.0 mL

Analyte		Result	Date Analyzed
As	21	ug/gram	1/09/91
Pb	48	ug/gram	1/09/91

NEA ID: 90-S60 Client ID: TS 1127914-C

Sample Mass: 0.2088 grams Extraction Volume: 25.0 mL

Analyte		Result	Date Analyzed
As	38	ug/gram	1/09/91
Pb	91	ug/gram	1/09/91

Client Name: Tacoma Slag Study
Date Received:

Report Date: 1/18/91
Project Number: 316/001

NEA ID: 90-S61 Client ID: TS 1127914-D

Sample Mass: 0.4884 grams Extraction Volume: 25.0 mL

Analyte		Result	Date Analyzed
As	27	ug/gram	1/09/91
Pb	61	ug/gram	1/09/91

NEA ID: 90-S62 Client ID: TS 1127917-A

Sample Mass: 0.4988 grams Extraction Volume: 25.0 mL

Analyte		Result	Date Analyzed
As	16	ug/gram	1/14/91
Pb	30	ug/gram	1/14/91

NEA ID: 90-S63 Client ID: TS 1127917-B

Sample Mass: 0.5086 grams Extraction Volume: 25.0 mL

Analyte		Result	Date Analyzed
As	18	ug/gram	1/14/91
Pb	32	ug/gram	1/14/91

NEA ID: 90-S64 Client ID: TS 1127917-C

Sample Mass: 0.4940 grams Extraction Volume: 25.0 mL

Analyte		Result	Date Analyzed
As	23	ug/gram	1/14/91
Pb	43	ug/gram	1/14/91

NEA ID: 90-S65 Client ID: TS 1127917-D

Sample Mass: 0.5163 grams Extraction Volume: 25.0 mL

Analyte		Result	Date Analyzed
As	29	ug/gram	1/14/91
Pb	53	ug/gram	1/14/91

Table A.1

Client Name: Tacoma Slag Study
Date Received:

Report Date: 1/18/91
Project Number: 316/001

NEA ID: 90-S66 Client ID: TS 1127918-A

Sample Mass: 0.5150 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	8.3	ug/gram	1/14/91
Pb	13	ug/gram	1/14/91

NEA ID: 90-S67 Client ID: TS 1127918-B

Sample Mass: 0.4933 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	12	ug/gram	1/14/91
Pb	23	ug/gram	1/14/91

NEA ID: 90-S68 Client ID: TS 1127918-C

Sample Mass: 0.4937 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	17	ug/gram	1/14/91
Pb	51	ug/gram	1/14/91

NEA ID: 90-S69 Client ID: TS 1127918-D

Sample Mass: 0.5064 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	19	ug/gram	1/14/91
Pb	49	ug/gram	1/14/91

NEA ID: 90-S80 Client ID: TS 1127921

Sample Area: 645.000 cm2 Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	3.2	ng/cm2	12/20/90
Pb	7.8	ng/cm2	12/31/90

Table A.1

Client Name: Tacoma Slag Study
Date Received:

Report Date: 1/18/91
Project Number: 316/001

NEA ID: 90-S81 Client ID: TS 1127922

Sample Area: 2580 cm2 Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	0.76	ng/cm2	12/20/90
Pb	1.3	ng/cm2	12/31/90

NEA ID: 90-S82 Client ID: TS 1127923

Sample Area: 2580 cm2 Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	<0.01	ng/cm2	12/20/90
Pb	0.16	ng/cm2	12/31/90

NEA ID: 90-S83 Client ID: TS 1127924

Sample Area: 2580 cm2 Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	0.97	ng/cm2	12/20/90
Pb	1.6	ng/cm2	1/03/91

NEA ID: 90-S84 Client ID: TS 1127925-A

Sample Mass: 0.4998 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	75	ug/gram	1/14/91
Pb	80	ug/gram	1/14/91

NEA ID: 90-S85 Client ID: TS 1127925-B

Sample Mass: 0.5080 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	69	ug/gram	1/14/91
Pb	120	ug/gram	1/14/91

Table A.1

Client Name: Tacoma Slag Study
Date Received:

Report Date: 1/18/91
Project Number: 316/001

NEA ID: 90-S86 Client ID: TS 1127925-C

Sample Mass: 0.4921 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	110	ug/gram	1/14/91
Pb	150	ug/gram	1/14/91

NEA ID: 90-S87 Client ID: TS 1127925-D

Sample Mass: 0.4941 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	170	ug/gram	1/14/91
Pb	200	ug/gram	1/14/91

NEA ID: 90-S88 Client ID: TS 1127926-A

Sample Mass: 0.4995 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	180	ug/gram	1/02/91
Pb	110	ug/gram	1/02/91

NEA ID: 90-S89 Client ID: TS 1127926-B

Sample Mass: 0.5089 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	140	ug/gram	1/02/91
Pb	190	ug/gram	1/02/91

NEA ID: 90-S90 Client ID: TS 1127926-C

Sample Mass: 0.5177 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	230	ug/gram	1/02/91
Pb	250	ug/gram	1/02/91

Table A.1

Client Name: Tacoma Slag Study
Date Received:

Report Date: 1/18/91
Project Number: 316/001

NEA ID: 90-S91 Client ID: TS 1127926-D

Sample Mass: 0.5243 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	360	ug/gram	1/02/91
Pb	250	ug/gram	1/02/91

NEA ID: 90-S92 Client ID: TS 1127927-A

Sample Mass: 0.3682 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	520	ug/gram	1/02/91
Pb	240	ug/gram	1/02/91

NEA ID: 90-S93 Client ID: TS 1127927-B

Sample Mass: 0.0095 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	290	ug/gram	1/02/91
Pb	150	ug/gram	1/02/91

NEA ID: 90-S94 Client ID: TS 1127927-C

Sample Mass: 0.5393 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	460	ug/gram	1/02/91
Pb	210	ug/gram	1/02/91

NEA ID: 90-S95 Client ID: TS 1127927-D

Sample Mass: 0.4350 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	690	ug/gram	1/02/91
Pb	290	ug/gram	1/02/91

Table A.1

Client Name:	Tacoma Slag Study	Report Date:	1/18/91
Date Received:		Project Number:	316/001

NEA ID: 90-S96 Client ID: TS 1127930-A

Sample Mass: 0.5040 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	60	ug/gram	1/14/91
Pb	69	ug/gram	1/14/91

NEA ID: 90-S97 Client ID: TS 1127930-B

Sample Mass: 0.5014 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	55	ug/gram	1/14/91
Pb	65	ug/gram	1/14/91

NEA ID: 90-S98 Client ID: TS 1127930-C

Sample Mass: 0.0821 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
Pb	490	ug/gram	1/14/91
As	67	ug/gram	1/14/91

NEA ID: 90-S99 Client ID: TS 1127930-D

Sample Mass: 0.2466 grams Extraction Volume: 26.0 mL

Analyte	Result		Date Analyzed
Pb	180	ug/gram	1/14/91
As	71	ug/gram	1/14/91

NEA ID: 90-S100 Client ID: TS 1127931-A

Sample Mass: 0.4977 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	60	ug/gram	1/14/91
Pb	70	ug/gram	1/14/91

Client Name: Tacoma Slag Study
Date Received:

Report Date: 1/18/91
Project Number: 316/001

NEA ID: 90-S101 Client ID: TS 1127931-B

Sample Mass: 0.4957 grams Extraction Volume: 26.0 mL

Analyte	Result		Date Analyzed
Pb	63	ug/gram	1/14/91
As	45	ug/gram	1/14/91

NEA ID: 90-S102 Client ID: TS 1127931-C

Sample Mass: 0.1766 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
Pb	170	ug/gram	1/14/91
As	64	ug/gram	1/14/91

NEA ID: 90-S103 Client ID: TS 1127931-D

Sample Mass: 0.2424 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	62	ug/gram	1/14/91
Pb	100	ug/gram	1/14/91

NEA ID: 90-S104 Client ID: TS 1127932-A

Sample Mass: 0.5154 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	63	ug/gram	1/14/91
Pb	87	ug/gram	1/14/91

NEA ID: 90-S105 Client ID: TS 1127932-B

Sample Mass: 0.5063 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
Pb	49	ug/gram	1/14/91
As	48	ug/gram	1/14/91

Client Name: Tacoma Slag Study
Date Received:

Report Date: 1/18/91
Project Number: 316/001

NEA ID: 90-S106 Client ID: TS 1127932-C

Sample Mass: 0.4940 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
Pb	150	ug/gram	1/14/91
As	43	ug/gram	1/14/91

NEA ID: 90-S107 Client ID: TS 1127932-D

Sample Mass: 0.5114 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
Pb	100	ug/gram	1/14/91
As	54	ug/gram	1/14/91

NEA ID: 90-S108 Client ID: TS 1127933-A

Sample Mass: 0.4930 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	61	ug/gram	1/21/91
Pb	66	ug/gram	1/21/91

NEA ID: 90-S109 Client ID: TS 1127933-B

Sample Mass: 0.5108 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	39	ug/gram	1/14/91
Pb	42	ug/gram	1/14/91

NEA ID: 90-S110 Client ID: TS 1127933-C

Sample Mass: 0.4969 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	47	ug/gram	1/14/91
Pb	46	ug/gram	1/14/91

Table A.1

Client Name: Tacoma Slag Study
Date Received:

Report Date: 1/18/91
Project Number: 316/001

NEA ID: 90-S111 Client ID: TS 1127933-D

Sample Mass: 0.4944 grams Extraction Volume: 25.0 mL

Analyte		Result	Date Analyzed
As	61	ug/gram	1/14/91
Pb	71	ug/gram	1/14/91

NEA ID: 90-S112 Client ID: TS 1127934-A

Sample Mass: 0.4994 grams Extraction Volume: 25.0 mL

Analyte		Result	Date Analyzed
As	50	ug/gram	1/14/91
Pb	55	ug/gram	1/14/91

NEA ID: 90-S113 Client ID: TS 1127934-B

Sample Mass: 0.5015 grams Extraction Volume: 25.0 mL

Analyte		Result	Date Analyzed
As	42	ug/gram	1/14/91
Pb	55	ug/gram	1/14/91

NEA ID: 90-S114 Client ID: TS 1127934-C

Sample Mass: 0.0191 grams Extraction Volume: 25.0 mL

Analyte		Result	Date Analyzed
As	81	ug/gram	1/14/91
Pb	630	ug/gram	1/14/91

NEA ID: 90-S115 Client ID: TS 1127934-D

Sample Mass: 0.1959 grams Extraction Volume: 25.0 mL

Analyte		Result	Date Analyzed
Pb	2300	ug/gram	1/14/91
As	680	ug/gram	1/14/91

Table A.1

Client Name: Tacoma Slag Study — Report Date: 1/18/91
Date Received: — Project Number: 316/001

NEA ID: 90-S126 Client ID: TS 1127939-A

Sample Mass: 0.4960 grams Extraction Volume: 25.0 mL

Analyte		Result	Date Analyzed
As	24	ug/gram	1/14/91
Pb	33	ug/gram	1/14/91

NEA ID: 90-S127 Client ID: TS 1127939-B

Sample Mass: 0.4927 grams Extraction Volume: 25.0 mL

Analyte		Result	Date Analyzed
Pb	86	ug/gram	1/14/91
As	40	ug/gram	1/14/91

NEA ID: 90-S128 Client ID: TS 1127939-C

Sample Mass: 0.4941 grams Extraction Volume: 25.0 mL

Analyte		Result	Date Analyzed
Pb	110	ug/gram	1/14/91
As	61	ug/gram	1/14/91

NEA ID: 90-S130 Client ID: TS 1127940

Sample Area: 2580.00 cm2 Extraction Volume: 25.0 mL

Analyte		Result	Date Analyzed
As	1.5	ng/cm2	12/20/90
Pb	1.6	ng/cm2	12/31/90

NEA ID: 90-S131 Client ID: TS 1127941-A

Sample Mass: 0.5398 grams Extraction Volume: 25.0 mL

Analyte		Result	Date Analyzed
As	300	ug/gram	1/02/91
Pb	160	ug/gram	1/02/91

Table A.1

Client Name: Tacoma Slag Study
Date Received:

Report Date: 1/18/91
Project Number: 316/001

NEA ID: 90-S132 Client ID: TS 1127941-B

Sample Mass: 0.0036 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	580	ug/gram	1/02/91
Pb	500	ug/gram	1/02/91

NEA ID: 90-S133 Client ID: TS 1127941-C

Sample Mass: 0.4923 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	250	ug/gram	1/02/91
Pb	220	ug/gram	1/02/91

NEA ID: 90-S134 Client ID: TS 1127941-D

Sample Mass: 0.5049 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	300	ug/gram	1/02/91
Pb	280	ug/gram	1/02/91

NEA ID: 90-S135 Client ID: TS 1127942

Sample Area: 645 cm2 Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	580	ng/cm2	12/20/90
Pb	580	ng/cm2	12/31/90

NEA ID: 90-S136 Client ID: TS 1127943

Sample Mass: 0.2717 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	150	ug/gram	1/02/91
Pb	130	ug/gram	1/02/91

Table A.1

Client Name: Tacoma Slag Study
Date Received:

Report Date: 1/18/91
Project Number: 316/001

NEA ID: 90-S137 Client ID: TS 1127944

Sample Area: 645 cm2 Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	390	ng/cm2	12/20/90
Pb	360	ng/cm2	12/31/90

NEA ID: 90-S138 Client ID: TS 1127945

Sample Area: Wipe Blank Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	< 25	Total ng	12/20/90
Pb	420	Total ng	12/31/90

NEA ID: 90-S139 Client ID: TS 1127904-A

Sample Mass: 0.5026 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	50	ug/gram	1/14/91
Pb	85	ug/gram	1/14/91

NEA ID: 90-S144 Client ID: TS 1127904-B

Sample Mass: 0.4979 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	55	ug/gram	1/14/91
Pb	140	ug/gram	1/14/91

NEA ID: 90-S149 Client ID: TS 1127956/CM1

Sample Mass: 0.4952 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	240	ug/gram	1/02/91
Pb	27000	ug/gram	1/02/91

Table A.1

Client Name: Tacoma Slag Study
Date Received:

Report Date: 1/18/91
Project Number: 316/001

NEA ID: 90-S150 Client ID: TS 1127957/CM1

Sample Mass: 0.5106 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	.83	ug/gram	1/02/90
Pb	5.4	ug/gram	1/02/90

NEA ID: 90-S151 Client ID: TS 1127958

Sample Mass: 0.1380 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	5400	ug/gram	1/02/91
Pb	83	ug/gram	1/02/91

NEA ID: 90-S152 Client ID: TS 1127959

Sample Mass: 0.8261 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	7000	ug/gram	1/02/91
Pb	23000	ug/gram	1/02/91

NEA ID: 90-S153 Client ID: TS 1127948-A

Sample Mass: 0.4537 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	240	ug/gram	1/02/90
Pb	190	ug/gram	1/02/90

NEA ID: 90-S155 Client ID: TS 1127948-C

Sample Mass: 0.4528 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	180	ug/gram	1/02/91
Pb	230	ug/gram	1/02/91

Table A.1

Client Name: Tacoma Slag Study
Date Received:

Report Date: 1/18/91
Project Number: 316/001

NEA ID: 90-S156 Client ID: TS 1127948-D

Sample Mass: 0.0292 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	390	ug/gram	1/02/91
Pb	400	ug/gram	1/02/91

NEA ID: 90-S158 Client ID: TS 1127943-B

Sample Mass: 0.0707 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	95	ug/gram	1/02/91
Pb	130	ug/gram	1/02/91

NEA ID: 90-S159 Client ID: TS 1127943-C

Sample Mass: 0.2123 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	190	ug/gram	1/02/91
Pb	270	ug/gram	1/02/91

NEA ID: 90-S160 Client ID: TS 1127943-D

Sample Mass: 0.0277 grams Extraction Volume: 25.0 mL

Analyte	Result		Date Analyzed
As	380	ug/gram	1/02/91
Pb	500	ug/gram	1/02/91

Table A.1

Client Name: Tacoma Slag Study
Date Received:

Project Number: 316/001
Report Date: 1/18/91

NEA ID: 90-W132 Client ID: 1127905

Analyte	Result		Det. Limit	Analysis Date
GFAA Ext V	50.0 mL			
As	150 ug/L	7.5 ug total	1 ug/L	1/02/91
Pb	41 ug/L	20 ug total	2 ug/L	1/02/91

NEA ID: 90-W133 Client ID: 1127912

Analyte	Result		Det. Limit	Analysis Date
GFAA Ext V	50.0 mL			
As	1.0 ug/L	.05 ug total	1 ug/L	1/02/91
Pb	2.7 ug/L	.14 ug total	2 ug/L	1/02/91

NEA ID: 90-W134 Client ID: SPATULA RINSE

Analyte	Result		Det. Limit	Analysis Date
GFAA Ext V	50.0 mL			
As	7.6 ug/L	.76 ug total	1 ug/L	1/02/91
Pb	< 2 ug/L	<.1 ug total	2 ug/L	1/02/91

NEA ID: 90-W135 Client ID: SOIL CORE SAMPLE RINSE

Analyte	Result		Det. Limit	Analysis Date
GFAA Ext V	50.0 mL			
As	< 1 ug/L	<.05 ug total	1 ug/L	1/02/91
Pb	< 2 ug/L	<.1 ug total	2 ug/L	1/02/91

NEA ID: 90-W136 Client ID: TS 1127928

Analyte	Result		Det. Limit	Analysis Date
GFAA Ext V	50.0 mL			
As	1200 ug/L	60 ug total	1 ug/L	1/02/91
Pb	700 ug/L	35 ug total	2 ug/L	1/02/91

Client Name: Tacoma Slag Study — Project Number: 316/001
Date Received: — Report Date: 1/18/91

NEA ID: 90-W137 Client ID: TS 1127929

Analyte	Result		Det. Limit	Analysis Date
GFAA Ext V	50.0 mL			
As	2500 ug/L	120 ug total	1 ug/L	1/02/91
Pb	1000 ug/L	50 ug total	2 ug/L	1/02/91

NEA ID: 90-W138 Client ID: TS 1127937

Analyte	Result		Det. Limit	Analysis Date
GFAA Ext V	50.0 mL			
As	< 1 ug/L	<.05 ug total	1 ug/L	1/02/91
Pb	2.0 ug/L	.1 ug total	2 ug/L	1/02/91

NEA ID: 90-W139 Client ID: TS 1127938

Analyte	Result		Det. Limit	Analysis Date
GFAA Ext V	50.0 mL			
As	4.9 ug/L	.24 ug total	1 ug/L	1/02/91
Pb	5.4 ug/L	.27 ug total	2 ug/L	1/02/91

NEA ID: 90-W140 Client ID: TS 1127946

Analyte	Result		Det. Limit	Analysis Date
GFAA Ext V	50.0 mL			
As	900 ug/L	45 ug total	1 ug/L	1/02/91
Pb	760 ug/L	38 ug total	2 ug/L	1/02/91

NEA ID: 90-W141 Client ID: TS 1127947

Analyte	Result		Det. Limit	Analysis Date
GFAA Ext V	50.0 mL			
As	1100 ug/L	55 ug total	1 ug/L	1/02/91
Pb	1400 ug/L	70 ug total	2 ug/L	1/02/91

Table A.1

Client Name: Tacoma Slag Study Project Number: 316/001
Date Received: Report Date: 1/18/91

NEA ID: 90-W142 Client ID: TS 1127949

Analyte	Result		Det. Limit	Analysis Date
GFAA Ext V	50.0 mL			
As	510 ug/L	26 ug total	1 ug/L	1/02/91
Pb	640 ug/L	32 ug total	2 ug/L	1/02/91

NEA ID: 90-W143 Client ID: TS 1127952

Analyte	Result		Det. Limit	Analysis Date
GFAA Ext V	310 mL			
As	5.0 ug/L	1.6 ug total	1 ug/L	1/17/91
Pb	4.0 ug/L	1.2 ug total	2 ug/L	1/17/91

NEA ID: 90-W144 Client ID: TS 1127955

Analyte	Result		Det. Limit	Analysis Date
GFAA Ext V	280 mL			
As	16 ug/L	4.5 ug total	1 ug/L	1/17/91
Pb	4.9 ug/L	1.4 ug total	2 ug/L	1/17/91

Table A.1

Sample ID: 90-833 Client ID: TS 1127906-E
Exposed Area: 6.60 cm2
Deposit Mass: 877. +- 10. ug

Element	ug/cm2			ug/filter			percent		
Al	2.626	+-	0.3677	17.33	+-	2.427	1.976	+-	0.2776
Si	16.79	+-	2.223	110.8	+-	14.67	12.64	+-	1.679
P	0.0000	+-	0.0084	0.0000	+-	0.0554	0.0000	+-	0.0063
S	0.0000	+-	0.2119	0.0000	+-	1.399	0.0000	+-	0.1595
Cl	0.0000	+-	0.0302	0.0000	+-	0.1993	0.0000	+-	0.0227
K	0.5155	+-	0.0584	3.402	+-	0.3854	0.3879	+-	0.0442
Ca	3.015	+-	0.3374	19.90	+-	2.227	2.269	+-	0.2552
Ti	0.3539	+-	0.0183	2.336	+-	0.1208	0.2663	+-	0.0141
V	0.0000	+-	0.0045	0.0000	+-	0.0297	0.0000	+-	0.0034
Cr	0.0938	+-	0.0054	0.6191	+-	0.0356	0.0706	+-	0.0041
Mn	0.0000	+-	0.0033	0.0000	+-	0.0218	0.0000	+-	0.0025
Fe	22.47	+-	1.113	148.3	+-	7.346	16.91	+-	0.8595
Ni	0.0000	+-	0.0033	0.0000	+-	0.0218	0.0000	+-	0.0025
Cu	2.433	+-	0.1236	16.06	+-	0.8158	1.831	+-	0.0953
Zn	0.8015	+-	0.0413	5.290	+-	0.2726	0.6032	+-	0.0318
Ga	0.0000	+-	0.0035	0.0000	+-	0.0231	0.0000	+-	0.0026
Ge	0.0000	+-	0.0018	0.0000	+-	0.0119	0.0000	+-	0.0014
As	2.272	+-	0.1297	15.00	+-	0.8560	1.710	+-	0.0995
Se	0.0000	+-	0.0020	0.0000	+-	0.0132	0.0000	+-	0.0015
Br	0.0000	+-	0.0086	0.0000	+-	0.0568	0.0000	+-	0.0065
Rb	0.0000	+-	0.0019	0.0000	+-	0.0125	0.0000	+-	0.0014
Sr	0.0154	+-	0.0020	0.1016	+-	0.0132	0.0116	+-	0.0015
Y	0.0000	+-	0.0023	0.0000	+-	0.0152	0.0000	+-	0.0017
Zr	0.0000	+-	0.0043	0.0000	+-	0.0284	0.0000	+-	0.0032
Mo	0.1855	+-	0.0106	1.224	+-	0.0700	0.1396	+-	0.0081
Pd	0.0036	+-	0.0166	0.0238	+-	0.1096	0.0027	+-	0.0125
Ag	0.0000	+-	0.0194	0.0000	+-	0.1280	0.0000	+-	0.0146
Cd	0.0414	+-	0.0212	0.2732	+-	0.1399	0.0312	+-	0.0160
In	0.0000	+-	0.0214	0.0000	+-	0.1412	0.0000	+-	0.0161
Sn	0.0653	+-	0.0236	0.4310	+-	0.1558	0.0491	+-	0.0178
Sb	0.4552	+-	0.0365	3.004	+-	0.2409	0.3426	+-	0.0277
Ba	0.0000	+-	0.0836	0.0000	+-	0.5518	0.0000	+-	0.0629
La	0.1476	+-	0.1133	0.9742	+-	0.7478	0.1111	+-	0.0853
Hg	0.0000	+-	0.0036	0.0000	+-	0.0238	0.0000	+-	0.0027
Pb	1.322	+-	0.0669	8.725	+-	0.4415	0.9949	+-	0.0516

Table A.1

Sample ID: 91-620 Client ID: TS 1127950-1-E
Exposed Area: 6.60 cm2
Deposit Mass: 784. +- 10. ug

Element	ug/cm2			ug/filter			percent		
Al	1.827	+-	0.2628	12.06	+-	1.734	1.538	+-	0.2221
Si	14.19	+-	1.878	93.65	+-	12.39	11.95	+-	1.588
P	0.0000	+-	0.0075	0.0000	+-	0.0495	0.0000	+-	0.0063
S	0.0000	+-	0.1837	0.0000	+-	1.212	0.0000	+-	0.1546
Cl	0.0000	+-	0.0270	0.0000	+-	0.1782	0.0000	+-	0.0227
K	0.3615	+-	0.0413	2.386	+-	0.2726	0.3043	+-	0.0350
Ca	3.123	+-	0.3495	20.61	+-	2.307	2.629	+-	0.2961
Ti	0.2963	+-	0.0155	1.956	+-	0.1023	0.2494	+-	0.0134
V	0.0000	+-	0.0040	0.0000	+-	0.0264	0.0000	+-	0.0034
Cr	0.0418	+-	0.0032	0.2759	+-	0.0211	0.0352	+-	0.0027
Mn	0.0000	+-	0.0031	0.0000	+-	0.0205	0.0000	+-	0.0026
Fe	23.24	+-	1.151	153.4	+-	7.597	19.56	+-	1.001
Ni	0.0000	+-	0.0032	0.0000	+-	0.0211	0.0000	+-	0.0027
Cu	2.222	+-	0.1129	14.67	+-	0.7451	1.871	+-	0.0980
Zn	1.662	+-	0.0851	10.97	+-	0.5617	1.399	+-	0.0738
Ga	0.0000	+-	0.0037	0.0000	+-	0.0244	0.0000	+-	0.0031
Ge	0.0000	+-	0.0021	0.0000	+-	0.0139	0.0000	+-	0.0018
As	5.483	+-	0.2767	36.19	+-	1.826	4.616	+-	0.2403
Se	0.0000	+-	0.0026	0.0000	+-	0.0172	0.0000	+-	0.0022
Br	0.0000	+-	0.0196	0.0000	+-	0.1294	0.0000	+-	0.0165
Rb	0.0000	+-	0.0029	0.0000	+-	0.0191	0.0000	+-	0.0024
Sr	0.0053	+-	0.0019	0.0350	+-	0.0125	0.0045	+-	0.0016
Y	0.0000	+-	0.0023	0.0000	+-	0.0152	0.0000	+-	0.0019
Zr	0.0000	+-	0.0045	0.0000	+-	0.0297	0.0000	+-	0.0038
Mo	0.2079	+-	0.0121	1.372	+-	0.0799	0.1750	+-	0.0104
Pd	0.0364	+-	0.0182	0.2402	+-	0.1201	0.0306	+-	0.0153
Ag	0.0352	+-	0.0201	0.2323	+-	0.1327	0.0296	+-	0.0169
Cd	0.0434	+-	0.0217	0.2864	+-	0.1432	0.0365	+-	0.0183
In	0.0000	+-	0.0219	0.0000	+-	0.1445	0.0000	+-	0.0184
Sn	0.0439	+-	0.0240	0.2897	+-	0.1584	0.0370	+-	0.0202
Sb	0.6575	+-	0.0448	4.340	+-	0.2957	0.5535	+-	0.0384
Ba	0.0009	+-	0.0773	0.0059	+-	0.5102	0.0008	+-	0.0651
La	0.0000	+-	0.1071	0.0000	+-	0.7069	0.0000	+-	0.0902
Hg	0.0000	+-	0.0043	0.0000	+-	0.0284	0.0000	+-	0.0036
Pb	1.380	+-	0.0698	9.108	+-	0.4607	1.162	+-	0.0606

Table A.1

Sample ID: 91-S21 Client ID: TS 1127953-4-E
Exposed Area: 6.60 cm2
Deposit Mass: 843. +- 10. ug

Element	ug/cm2		ug/filter		percent	
Al	4.231	+- 0.5834	27.92	+- 3.850	3.313	+- 0.4584
Si	23.22	+- 3.073	153.3	+-20.28	18.18	+- 2.416
P	0.0000	+- 0.0090	0.0000	+- 0.0594	0.0000	+- 0.0070
S	0.0000	+- 0.2214	0.0000	+- 1.461	0.0000	+- 0.1733
Cl	0.0000	+- 0.0317	0.0000	+- 0.2092	0.0000	+- 0.0248
K	0.5989	+- 0.0678	3.953	+- 0.4475	0.4689	+- 0.0534
Ca	4.004	+- 0.4480	26.43	+- 2.957	3.135	+- 0.3527
Ti	0.3873	+- 0.0200	2.556	+- 0.1320	0.3032	+- 0.0161
V	0.0000	+- 0.0048	0.0000	+- 0.0317	0.0000	+- 0.0038
Cr	0.0538	+- 0.0038	0.3551	+- 0.0251	0.0421	+- 0.0030
Mn	0.0000	+- 0.0034	0.0000	+- 0.0224	0.0000	+- 0.0027
Fe	24.76	+- 1.227	163.4	+- 8.098	19.39	+- 0.9878
Ni	0.0000	+- 0.0031	0.0000	+- 0.0205	0.0000	+- 0.0024
Cu	1.725	+- 0.0878	11.38	+- 0.5795	1.351	+- 0.0706
Zn	1.078	+- 0.0553	7.115	+- 0.3650	0.8440	+- 0.0444
Ga	0.0000	+- 0.0034	0.0000	+- 0.0224	0.0000	+- 0.0027
Ge	0.0000	+- 0.0019	0.0000	+- 0.0125	0.0000	+- 0.0015
As	2.114	+- 0.1258	13.95	+- 0.8303	1.655	+- 0.1004
Se	0.0000	+- 0.0019	0.0000	+- 0.0125	0.0000	+- 0.0015
Br	0.0000	+- 0.0082	0.0000	+- 0.0541	0.0000	+- 0.0064
Rb	0.0000	+- 0.0019	0.0000	+- 0.0125	0.0000	+- 0.0015
Sr	0.0169	+- 0.0020	0.1115	+- 0.0132	0.0132	+- 0.0016
Y	0.0000	+- 0.0023	0.0000	+- 0.0152	0.0000	+- 0.0018
Zr	0.0000	+- 0.0044	0.0000	+- 0.0290	0.0000	+- 0.0034
Mo	0.1381	+- 0.0085	0.9115	+- 0.0561	0.1081	+- 0.0068
Pd	0.0117	+- 0.0162	0.0772	+- 0.1069	0.0092	+- 0.0127
Ag	0.0000	+- 0.0189	0.0000	+- 0.1247	0.0000	+- 0.0148
Cd	0.0416	+- 0.0208	0.2746	+- 0.1373	0.0326	+- 0.0163
In	0.0000	+- 0.0204	0.0000	+- 0.1346	0.0000	+- 0.0160
Sn	0.0903	+- 0.0229	0.5960	+- 0.1511	0.0707	+- 0.0179
Sb	0.5718	+- 0.0402	3.774	+- 0.2653	0.4477	+- 0.0319
Ba	0.0124	+- 0.0800	0.0818	+- 0.5280	0.0097	+- 0.0626
La	0.0000	+- 0.1090	0.0000	+- 0.7194	0.0000	+- 0.0853
Hg	0.0000	+- 0.0038	0.0000	+- 0.0251	0.0000	+- 0.0030
Pb	1.414	+- 0.0715	9.332	+- 0.4719	1.107	+- 0.0575

Sample ID: 91-822 Client ID: TS 1127926-E
Exposed Area: 6.60 cm2
Deposit Mass: 756. +- 10. ug

Element	ug/cm2			ug/filter			percent		
Al	2.255	+-	0.3157	14.88	+-	2.084	1.969	+-	0.2768
Si	14.45	+-	1.913	95.37	+-	12.63	12.62	+-	1.678
P	0.0000	+-	0.0076	0.0000	+-	0.0502	0.0000	+-	0.0066
S	0.0000	+-	0.1593	0.0000	+-	1.051	0.0000	+-	0.1391
Cl	0.0000	+-	0.0244	0.0000	+-	0.1610	0.0000	+-	0.0213
K	0.4795	+-	0.0544	3.165	+-	0.3590	0.4186	+-	0.0478
Ca	2.840	+-	0.3179	18.74	+-	2.098	2.479	+-	0.2795
Ti	0.3190	+-	0.0166	2.105	+-	0.1096	0.2785	+-	0.0150
V	0.0000	+-	0.0041	0.0000	+-	0.0271	0.0000	+-	0.0036
Cr	0.0742	+-	0.0045	0.4897	+-	0.0297	0.0648	+-	0.0040
Mn	0.0000	+-	0.0030	0.0000	+-	0.0198	0.0000	+-	0.0026
Fe	19.62	+-	0.9721	129.5	+-	6.416	17.13	+-	0.8784
Ni	0.0000	+-	0.0034	0.0000	+-	0.0224	0.0000	+-	0.0030
Cu	2.043	+-	0.1039	13.48	+-	0.6857	1.784	+-	0.0937
Zn	0.6965	+-	0.0360	4.597	+-	0.2376	0.6081	+-	0.0324
Ga	0.0000	+-	0.0032	0.0000	+-	0.0211	0.0000	+-	0.0028
Ge	0.0000	+-	0.0020	0.0000	+-	0.0132	0.0000	+-	0.0017
As	1.811	+-	0.1031	11.95	+-	0.6805	1.581	+-	0.0924
Se	0.0000	+-	0.0020	0.0000	+-	0.0132	0.0000	+-	0.0017
Br	0.0000	+-	0.0070	0.0000	+-	0.0462	0.0000	+-	0.0061
Rb	0.0000	+-	0.0019	0.0000	+-	0.0125	0.0000	+-	0.0017
Sr	0.0101	+-	0.0019	0.0667	+-	0.0125	0.0088	+-	0.0017
Y	0.0000	+-	0.0023	0.0000	+-	0.0152	0.0000	+-	0.0020
Zr	0.0000	+-	0.0037	0.0000	+-	0.0244	0.0000	+-	0.0032
Mo	0.1638	+-	0.0093	1.081	+-	0.0614	0.1430	+-	0.0083
Pd	0.0000	+-	0.0153	0.0000	+-	0.1010	0.0000	+-	0.0134
Ag	0.0000	+-	0.0178	0.0000	+-	0.1175	0.0000	+-	0.0155
Cd	0.0044	+-	0.0194	0.0290	+-	0.1280	0.0038	+-	0.0169
In	0.0000	+-	0.0196	0.0000	+-	0.1294	0.0000	+-	0.0171
Sn	0.0119	+-	0.0217	0.0785	+-	0.1432	0.0104	+-	0.0189
Sb	0.3492	+-	0.0316	2.305	+-	0.2086	0.3049	+-	0.0279
Ba	0.1147	+-	0.0784	0.7570	+-	0.5174	0.1001	+-	0.0685
La	0.1571	+-	0.1062	1.037	+-	0.7009	0.1372	+-	0.0927
Hg	0.0000	+-	0.0041	0.0000	+-	0.0271	0.0000	+-	0.0036
Pb	1.038	+-	0.0527	6.851	+-	0.3478	0.9062	+-	0.0475

Table A.1

Sample ID: 91-818 Client ID: TS 1127925-E
Exposed Area: 6.60 cm2
Deposit Mass: 938. +- 10. ug

Element	ug/cm2			ug/filter			percent		
Al	2.168	+-	0.2940	14.31	+-	1.940	1.525	+-	0.2075
Si	7.803	+-	1.033	51.50	+-	6.818	5.490	+-	0.7292
P	0.0780	+-	0.0204	0.5148	+-	0.1346	0.0549	+-	0.0144
S	3.090	+-	0.3482	20.39	+-	2.298	2.174	+-	0.2461
Cl	0.3491	+-	0.0489	2.304	+-	0.3227	0.2456	+-	0.0345
K	3.584	+-	0.4014	23.65	+-	2.649	2.522	+-	0.2837
Ca	13.23	+-	1.479	87.32	+-	9.761	9.309	+-	1.045
Ti	0.4616	+-	0.0236	3.047	+-	0.1558	0.3248	+-	0.0170
V	0.0099	+-	0.0053	0.0653	+-	0.0350	0.0070	+-	0.0037
Cr	0.0336	+-	0.0026	0.2218	+-	0.0172	0.0236	+-	0.0018
Mn	0.1636	+-	0.0085	1.080	+-	0.0561	0.1151	+-	0.0061
Fe	2.570	+-	0.1279	16.96	+-	0.8441	1.808	+-	0.0920
Ni	0.0081	+-	0.0015	0.0535	+-	0.0099	0.0057	+-	0.0011
Cu	0.0805	+-	0.0045	0.5313	+-	0.0297	0.0566	+-	0.0032
Zn	0.2563	+-	0.0134	1.692	+-	0.0884	0.1803	+-	0.0096
Ga	0.0000	+-	0.0012	0.0000	+-	0.0079	0.0000	+-	0.0008
Ge	0.0000	+-	0.0008	0.0000	+-	0.0053	0.0000	+-	0.0006
As	0.0476	+-	0.0050	0.3142	+-	0.0330	0.0335	+-	0.0035
Se	0.0000	+-	0.0008	0.0000	+-	0.0053	0.0000	+-	0.0006
Br	0.0256	+-	0.0018	0.1690	+-	0.0119	0.0180	+-	0.0013
Rb	0.0038	+-	0.0013	0.0251	+-	0.0086	0.0027	+-	0.0009
Sr	0.0745	+-	0.0041	0.4917	+-	0.0271	0.0524	+-	0.0029
Y	0.0000	+-	0.0017	0.0000	+-	0.0112	0.0000	+-	0.0012
Zr	0.0296	+-	0.0032	0.1954	+-	0.0211	0.0208	+-	0.0023
Mo	0.0036	+-	0.0029	0.0238	+-	0.0191	0.0025	+-	0.0020
Pd	0.0000	+-	0.0088	0.0000	+-	0.0581	0.0000	+-	0.0062
Ag	0.0044	+-	0.0106	0.0290	+-	0.0700	0.0031	+-	0.0075
Cd	0.0137	+-	0.0118	0.0904	+-	0.0779	0.0096	+-	0.0083
In	0.0000	+-	0.0136	0.0000	+-	0.0898	0.0000	+-	0.0096
Sn	0.0000	+-	0.0167	0.0000	+-	0.1102	0.0000	+-	0.0118
Sb	0.0000	+-	0.0203	0.0000	+-	0.1340	0.0000	+-	0.0143
Ba	0.2311	+-	0.0791	1.525	+-	0.5221	0.1626	+-	0.0557
La	0.1893	+-	0.1052	1.249	+-	0.6943	0.1332	+-	0.0740
Hg	0.0000	+-	0.0017	0.0000	+-	0.0112	0.0000	+-	0.0012
Pb	0.0720	+-	0.0051	0.4752	+-	0.0337	0.0507	+-	0.0036

Tacoma Slag Study 316/001 Table A.1

Sample ID: 91-819 Client ID: TS 1127939-E
Exposed Area: 6.60 cm2
Deposit Mass: 589. +- 10. ug

Element	ug/cm2			ug/filter			percent		
Al	1.317	+-	0.1828	8.692	+-	1.206	1.476	+-	0.2064
Si	7.465	+-	0.9882	49.27	+-	6.522	8.365	+-	1.116
P	0.0000	+-	0.0066	0.0000	+-	0.0436	0.0000	+-	0.0074
S	0.8970	+-	0.1035	5.920	+-	0.6831	1.005	+-	0.1172
Cl	0.5247	+-	0.0611	3.463	+-	0.4033	0.5879	+-	0.0692
K	0.7782	+-	0.0876	5.136	+-	0.5782	0.8720	+-	0.0993
Ca	4.162	+-	0.4657	27.47	+-	3.074	4.664	+-	0.5278
Ti	0.3172	+-	0.0163	2.094	+-	0.1076	0.3554	+-	0.0192
V	0.0031	+-	0.0036	0.0205	+-	0.0238	0.0035	+-	0.0040
Cr	0.0241	+-	0.0018	0.1591	+-	0.0119	0.0270	+-	0.0021
Mn	0.0240	+-	0.0019	0.1584	+-	0.0125	0.0269	+-	0.0022
Fe	1.455	+-	0.0727	9.603	+-	0.4798	1.630	+-	0.0860
Ni	0.0026	+-	0.0012	0.0172	+-	0.0079	0.0029	+-	0.0013
Cu	0.0619	+-	0.0036	0.4085	+-	0.0238	0.0694	+-	0.0042
Zn	0.1107	+-	0.0060	0.7306	+-	0.0396	0.1240	+-	0.0070
Ga	0.0000	+-	0.0009	0.0000	+-	0.0059	0.0000	+-	0.0010
Ge	0.0007	+-	0.0007	0.0046	+-	0.0046	0.0008	+-	0.0008
As	0.0148	+-	0.0025	0.0977	+-	0.0165	0.0166	+-	0.0028
Se	0.0000	+-	0.0007	0.0000	+-	0.0046	0.0000	+-	0.0008
Br	0.0036	+-	0.0009	0.0238	+-	0.0059	0.0040	+-	0.0010
Rb	0.0003	+-	0.0011	0.0020	+-	0.0073	0.0003	+-	0.0012
Sr	0.0127	+-	0.0015	0.0838	+-	0.0099	0.0142	+-	0.0017
Y	0.0000	+-	0.0017	0.0000	+-	0.0112	0.0000	+-	0.0019
Zr	0.1554	+-	0.0084	1.026	+-	0.0554	0.1741	+-	0.0099
Mo	0.0018	+-	0.0030	0.0119	+-	0.0198	0.0020	+-	0.0034
Pd	0.0000	+-	0.0073	0.0000	+-	0.0482	0.0000	+-	0.0082
Ag	0.0163	+-	0.0093	0.1076	+-	0.0614	0.0183	+-	0.0104
Cd	0.0218	+-	0.0109	0.1439	+-	0.0719	0.0244	+-	0.0122
In	0.0000	+-	0.0128	0.0000	+-	0.0845	0.0000	+-	0.0143
Sn	0.0153	+-	0.0159	0.1010	+-	0.1049	0.0171	+-	0.0178
Sb	0.0514	+-	0.0199	0.3392	+-	0.1313	0.0576	+-	0.0223
Ba	0.0293	+-	0.0765	0.1934	+-	0.5049	0.0328	+-	0.0857
La	0.0345	+-	0.1060	0.2277	+-	0.6996	0.0387	+-	0.1188
Hg	0.0000	+-	0.0014	0.0000	+-	0.0092	0.0000	+-	0.0016
Pb	0.0285	+-	0.0035	0.1881	+-	0.0231	0.0319	+-	0.0040

Table A.1

REPLICATE REPORT
316/01
PROTOCOL: 4 SA

SAMPLE ID: TS1127953-4D
PARTICLE SIZE: C
ORIGINAL ID: S0021
REPLICATE ID: 00021
EXPOSED AREA: 6.60 SQUARE CM
MASS OF DEPOSIT: 0.+- 0. MICROGRAMS

ELEMENT	ORIGINAL UG/CM2		REPLICATE UG/CM2		CHANGE IN UG/CM2		PERCENT ERROR	
AL	4.3120+-	.5946	4.2657+-	.5883	-.0463+-	.8364	-1.1+-	19.4
SI	23.5355+-	3.1148	23.3224+-	3.0866	-.2131+-	4.3851	-.9+-	18.6
P	.0000+-	.0092	.0000+-	.0092	.0000+-	.0130		
S	.0000+-	.2224	.0000+-	.2188	.0000+-	.3120		
CL	.0000+-	.0319	.0000+-	.0310	.0000+-	.0445		
K	.6000+-	.0679	.6204+-	.0702	.0204+-	.0977	3.4+-	16.3
CA	4.0089+-	.4486	4.0410+-	.4522	.0321+-	.6370	.8+-	15.9
TI	.3873+-	.0200	.3943+-	.0203	.0070+-	.0285	1.8+-	7.4
V	.0000+-	.0048	.0000+-	.0049	.0000+-	.0069		
CR	.0538+-	.0038	.0596+-	.0040	.0058+-	.0055	10.8+-	10.3
MN	.0000+-	.0034	.0000+-	.0034	.0000+-	.0048		
FE	24.7643+-	1.2266	24.7223+-	1.2245	-.0420+-	1.7332	-.2+-	7.0
NI	.0000+-	.0031	.0000+-	.0031	.0000+-	.0044		
CU	1.7248+-	.0878	1.7201+-	.0875	-.0047+-	.1240	-.3+-	7.2
ZN	1.0775+-	.0553	1.0799+-	.0555	.0024+-	.0783	.2+-	7.3
GA	.0000+-	.0034	.0000+-	.0034	.0000+-	.0048		
GE	.0000+-	.0019	.0000+-	.0019	.0000+-	.0027		
AS	2.1140+-	.1258	2.1235+-	.1265	.0095+-	.1784	.4+-	8.4
SE	.0000+-	.0019	.0000+-	.0020	.0000+-	.0028		
BR	.0000+-	.0082	.0000+-	.0082	.0000+-	.0116		
RB	.0000+-	.0019	.0000+-	.0019	.0000+-	.0027		
SR	.0169+-	.0020	.0166+-	.0020	-.0003+-	.0028	-1.8+-	16.7
Y	.0000+-	.0023	.0000+-	.0023	.0000+-	.0033		
ZR	.0000+-	.0044	.0000+-	.0044	.0000+-	.0062		
MO	.1381+-	.0085	.1450+-	.0090	.0069+-	.0124	5.0+-	9.0
PD	.0117+-	.0162	.0256+-	.0164	.0139+-	.0231		
AG	.0000+-	.0189	.0000+-	.0189	.0000+-	.0267		
CD	.0416+-	.0208	.0398+-	.0205	-.0018+-	.0292		
IN	.0000+-	.0204	.0000+-	.0204	.0000+-	.0288		
SN	.0903+-	.0229	.0797+-	.0229	-.0106+-	.0324	-11.7+-	35.9
SB	.5718+-	.0402	.4768+-	.0365	-.0950+-	.0543	-16.6+-	9.5
BA	.0124+-	.0800	.0000+-	.0791	-.0124+-	.1125		
LA	.0000+-	.1090	.0560+-	.1084	.0560+-	.1537		
HG	.0000+-	.0038	.0000+-	.0038	.0000+-	.0054		
PB	1.4144+-	.0715	1.4238+-	.0720	.0094+-	.1015	.7+-	7.2

Table A.2

NEA INC.

QUALITY ASSURANCE REPORT

GFAA

SAMPLE RANGE: 90-W(143,144)
SAMPLE DESCRIPTION: Water samples

DUPLICATE ANALYSIS

DATE	ANALYSIS ID	ANALYTES	SAMPLE (ug/L)	DUPLICATE (ug/L)	RPD
1/17/91	90-W144	As	16.5	16.3	1.2
		Pb	4.9	4.9	0.0

PRE-DIGESTION SPIKE ANALYSIS

DATE	ANALYSIS ID	ANALYTES	SPIKE AMOUNT (ug/L)	SPIKE REC. (ug/L)	SPIKE % RECOVERY
1/17/91	90-W143 S_1	As	20.0	19.4	97.0
		Pb	10.0	10.7	107
	90-W143 S_2	As	20.0	20.4	102
		Pb	10.0	10.4	104

POST-DIGESTION SPIKE ANALYSIS

DATE	ANALYSIS ID	ANALYTES	SPIKE AMOUNT (ug/L)	SPIKE REC. (ug/L)	SPIKE % RECOVERY
1/17/91	90-W143	As	12.5	12.6	101
		Pb	5.0	4.8	96

RPD: Relative Percent Difference $[(X_1-X_2)/[(X_1+X_2)/2]*100$

SPIKE % RECOVERY:
[(sample+spike - unspiked sample)/spike added]*100

APPROVED BY: JCS DATE: 1/24/91

NEA INC.

QUALITY ASSURANCE REPORT

GFAA

SAMPLE RANGE: 90-W132 thru 90-W142
SAMPLE DESCRIPTION: Water and acetone/pentane rinses

DUPLICATE ANALYSIS

DATE	ANALYSIS ID	ANALYTES	SAMPLE (ug/L)	DUPLICATE (ug/L)	RPD
12/21/90	90-W137	As	2490	2470	0.8
	90-W141		1060	1120	5.5
12/27/90	90-W139	Pb	5.43	5.39	0.7
1/02/91	90-W137		1031	1073	4.0

POST-DIGESTION SPIKE ANALYSIS

DATE	ANALYSIS ID	ANALYTES	SPIKE AMOUNT (ug/L)	SPIKE REC. (ug/L)	SPIKE % RECOVERY
12/21/90	90-W136	As	12.5	10.2	81.6
	90-W141		12.5	11.4	91.2
12/27/90	90-W141	Pb	10.0	8.80	88.0
1/02/90	90-W137		25.0	26.5	106

RPD: Relative Percent Difference $[(X_1-X_2)/[(X_1+X_2)/2]*100$

SPIKE % RECOVERY:
[(sample+spike - unspiked sample)/spike added]*100

APPROVED BY: JCS DATE: 1/24/91

Table A.2

NEA INC.

QUALITY ASSURANCE REPORT

GFAA

SAMPLE RANGE: 90-S(22,23,80-83,130,135,137,138)
SAMPLE DESCRIPTION: Wipe Samples

DUPLICATE ANALYSIS

DATE	ANALYSIS ID	ANALYTES	SAMPLE (ug/L)	DUPLICATE (ug/L)	RPD
12/20/90	90-S81	As	77.6	73.4	5.6
	90-S137		10500	10100	3.9
12/31/90	90-S130	Pb	170	172	1.2
	90-S138		16.6	16.9	1.8
01/03/91	90-S83	Pb	174	172	1.2

POST-DIGESTION SPIKE ANALYSIS

DATE	ANALYSIS ID	ANALYTES	SPIKE AMOUNT (ug/L)	SPIKE REC. (ug/L)	% SPIKE RECOVERY
12/20/90	90-S23	As	12.5	11.1	88.8
	90-S137		12.5	11.4	91.2
12/31/90	90-S80	Pb	25.0	23.0	92.0
01/03/90	90-S83	Pb	25.0	27.9	112

RPD: Relative Percent Difference $[(X_1-X_2)/[(X_1+X_2)/2]*100$

SPIKE % RECOVERY:
[(sample+spike - unspiked sample)/spike added]*100

APPROVED BY: 9CS DATE: 1/24/91

Table A.2

NEA INC.

QUALITY ASSURANCE REPORT

GFAA and ICAP

SAMPLE RANGE: 90-S(24-27,88-95,131-136,149-153,155-156,158-160)
SAMPLE DESCRIPTION: Soil Samples

DUPLICATE ANALYSIS

DATE & INSTRUMENT	ANALYSIS ID	ANALYTES	SAMPLE (ug/ml)	DUPLICATE (ug/ml)	RPD
12/27/90	90-S26	Pb	1.75	1.84	5.0
ICAP	90-S91	Pb	5.20	5.09	2.1
		As	7.50	7.64	1.8
	90-S131	Pb	3.42	3.59	4.8
		As	6.54	6.28	4.1
12/28/90	90-S149	Pb	502	478	4.9
ICAP	90-S152	Pb	754	765	1.4
		As	227	221	2.7
12/28/90 GFAA	90-S158	Pb	.382	.381	0.3
12/31/90 GFAA	90-S156	Pb	.471	.461	2.1
01/02/91	90-S25	As	.275	.284	3.2
GFAA	90-S132	As	.083	.082	1.2
	90-S156	As	.458	.452	1.3

RPD: Relative Percent Difference $[(X_1-X_2)/[(X_1+X_2)/2]*100$

APPROVED BY: JCS DATE: 1/24/91

Table A.2

NEA INC.

QUALITY ASSURANCE REPORT

GFAA and ICAP

SAMPLE RANGE: 90-S(24-27,88-95,131-136,149-153,155-156,158-160)
SAMPLE DESCRIPTION: Soil Samples

POST-DIGESTION SPIKE ANALYSIS

DATE & INSTRUMENT	ANALYSIS ID	ANALYTES	SPIKE AMOUNT (ug/ml)	SPIKE REC. (ug/ml)	SPIKE % RECOVERY
12/28/90 ICAP	90-S24	Pb	2.5	2.67	107
		As	2.5	2.53	101
	90-S95	Pb	2.5	2.50	100
		As	2.5	2.57	103
	90-S89	Pb	2.5	2.60	104
		As	2.5	2.37	94.8
12/28/90 GFAA	90-S156	Pb	.025	.0248	99.2
01/02/91 GFAA	90-S25	As	.025	.0214	85.6

SPIKE % RECOVERY:
[(sample+spike - unspiked sample)/spike added]*100

APPROVED BY: JCS DATE: 1/24/91

Table A.2

NEA INC.

QUALITY ASSURANCE REPORT

GFAA and ICAP

SAMPLE RANGE: 90-S(34-37,39-42,44-47,49-52,54-57,58-61)
SAMPLE DESCRIPTION: Soil Samples

DUPLICATE ANALYSIS

DATE & INSTRUMENT	ANALYSIS ID	ANALYTES	SAMPLE (ug/ml)	DUPLICATE (ug/ml)	RPD
01/04/91 ICAP	90-S35	Pb	2.05	2.00	2.5
		As	1.22	1.31	7.1
	90-S40	Pb	4.59	4.58	0.2
		As	2.56	2.53	1.2
	90-S49	Pb	8.25	8.34	1.1
		As	2.42	2.38	1.7
01/09/91 GFAA	90-S50	Pb	.555	.551	0.7
	90-S60	Pb	.758	.758	0.0
	90-S57	As	.630	.623	1.1
	90-S60	As	.324	.313	3.4

PRE-DIGESTION SPIKE ANALYSIS : ICAP

ANALYSIS ID	ANALYTES	SPIKE AMOUNT (ug/ml)	SPIKE REC. (ug/ml)	SPIKE % RECOVERY
90-S35 S_1	Pb	2.0	2.13	106
	As	4.0	4.05	101
90-S44 S_1	Pb	2.0	2.02	101
	As	4.0	4.12	103
90-S44 S_2	Pb	2.0	1.99	99.5
	As	4.0	4.01	100
90-S46 S_1	Pb	2.0	1.63	81.5
	As	4.0	3.75	93.8
90-S46 S_2	Pb	2.0	1.80	90.0
	As	4.0	3.64	91.0

RPD: Relative Percent Difference $[(X_1-X_2)/[(X_1+X_2)/2]*100$

SPIKE % RECOVERY:
[(sample+spike - unspiked sample)/spike added]*100

APPROVED BY: JCS DATE: 1/24/91

Table A.2

NEA INC.

QUALITY ASSURANCE REPORT

GFAA and ICAP

SAMPLE RANGE: 90-S(34-37,39-42,44-47,49-52,54-57,58-61)
SAMPLE DESCRIPTION: Soil Samples

POST-DIGESTION SPIKE ANALYSIS

DATE & INSTRUMENT	ANALYSIS ID	ANALYTES	SPIKE AMOUNT (ug/ml)	SPIKE REC. (ug/ml)	SPIKE % RECOVERY
01/04/91 ICAP	90-S39	Pb	2.5	2.72	109
		As	2.5	2.88	115
	90-S41	Pb	2.5	2.70	108
		As	2.5	2.87	115
01/09/91 GFAA	90-S44	Pb	.025	.0232	92.8
		As	.025	.0228	91.2

SPIKE % RECOVERY:
[(sample+spike - unspiked sample)/spike added]*100

APPROVED BY: JCS DATE: 1/24/91

Table A.2

NEA INC.

QUALITY ASSURANCE REPORT

GFAA and ICAP

SAMPLE RANGE: 90-S(62-69,84-87,96-115,126-128,139,144)
91-S(1-17)
SAMPLE DESCRIPTION: Soil Samples

DUPLICATE ANALYSIS

DATE & INSTRUMENT	ANALYSIS ID	ANALYTES	SAMPLE (ug/ml)	DUPLICATE (ug/ml)	RPD
01/11/91	90-S64	As	.448	.452	0.9
GFAA	90-S85	As	1.34	1.36	1.5
	90-S100	As	1.30	1.32	1.5
01/13/91	90-S84	Pb	1.60	1.76	9.5
ICAP		As	1.51	1.57	3.9
	90-S99	Pb	1.65	1.62	1.8
	90-S108	Pb	1.27	1.27	0.0
		As	1.19	1.30	8.8
	91-S01	Pb	3.46	3.35	3.2
		As	1.43	1.45	1.4
01/14/91	90-S105	As	.969	.969	0.0
GFAA	90-S115	As	.531	.496	6.8
	90-S64	Pb	.848	.840	0.9
	90-S110	Pb	.922	.935	1.4
01/14/91	91-S13	Pb	54.3	53.6	1.3
ICAP		As	83.1	83.4	0.4
	91-S17	Pb	90.6	91.4	0.9
		As	137	136	0.7

RPD: Relative Percent Difference $[(X_1-X_2)/[(X_1+X_2)/2]*100$

APPROVED BY: JCS DATE: 1/24/91

Table A.2

NEA INC.

QUALITY ASSURANCE REPORT

GFAA and ICAP

SAMPLE RANGE: 90-S(62-69,84-87,96-115,126-128,139,144)
91-S(1-17)
SAMPLE DESCRIPTION: Soil Samples

PRE-DIGESTION SPIKE ANALYSIS : ICAP

DATE	ANALYSIS ID	ANALYTES	SPIKE AMOUNT (ug/ml)	SPIKE REC. (ug/ml)	SPIKE % RECOVERY
01/13/91	90-S63 S_2	Pb	4.0	3.46	86.6
		As	2.0	1.55	77.5
	90-S86 S_1	Pb	4.0	3.58	89.4
		As	2.0	2.15	107
	90-S86 S_2	Pb	4.0	3.58	89.4
		As	2.0	1.82	91.0
	90-S105 S_1	Pb	4.0	3.32	83.0
		As	2.0	1.61	80.5
	90-S105 S_2	Pb	4.0	3.40	85.0
		As	2.0	1.67	83.5
	90-S127 S_2	Pb	4.0	3.34	83.5
		As	2.0	1.80	90.0

POST-DIGESTION SPIKE ANALYSIS

DATE & INSTRUMENT	ANALYSIS ID	ANALYTES	SPIKE AMOUNT (ug/L)	SPIKE REC. (ug/L)	SPIKE % RECOVERY
01/11/91 GFAA	90-S69	As	25.0	22.0	88.0
01/14/91 GFAA	90-S114	As	25.0	25.0	100
	90-S111	Pb	25.0	27.1	108

SPIKE % RECOVERY:
[(sample+spike - unspiked sample)/spike added]*100

APPROVED BY: QCS DATE: 1/24/91

Table A.3

EPA LOCATION	AS CONC. ug/g >80	MASS g	AREA cm2	AS CONC. ug/cm2	AS CONC. ug/g >200	MASS g	AREA cm2	AS CONC. ug/cm2	AS CONC. ug/g >400	MASS g	AREA cm2	AS CONC. ug/cm2	AS CONC. ug/g <400	MASS g	AREA cm2	AS CONC. ug/cm2
1 RUG	95	.7	18813	.00	49	.3	18813	.00	180	.4	18813	.00	120	.05	18813	.00
2 RUG	180	1.2	25084	.01	140	3.4	25084	.02	230	12.9	25084	.12	360	11.7	25084	.17
2 MAT	520	.5	3819	.07	290	.1	3819	.01	460	1.9	3819	.23	690	2.6	3819	.47
3 ENTRY	300	2.9	25084	.03	580	.13	25084	.00	250	3.4	25084	.03	300	1.2	25084	.01
3 RUG	150	.4	18813	.00	95	.05	18813	.00	190	.45	18813	.00	380	.15	18813	.00
3 CARPORT	240	2.1	25084	.02			25084	.00	180	.6	25084	.00	390	.1	25084	.00

EPA LOCATION	PB CONC ug/g >80	MASS g	AREA cm2	PB CONC ug/cm2	PB CONC. ug/g >200	MASS g	AREA cm2	PB CONC, ug/cm2	PB CONC ug/g >400.	MASS g	AREA cm2	PB CONC. ug/cm2	PB CONC. ug/g <400	MASS g	AREA cm2	PB CONC ug/cm2
1 RUG	230	.7	18813	.01	170	.3	18813	.00	72	.4	18813	.00	270	.05	18813	.00
2 RUG	110	1.2	25084	.01	190	3.4	25084	.03	250	12.9	25084	.13	250	11.7	25084	.12
2 MAT	240	.5	3819	.03	150	.1	3819	.00	210	1.9	3819	.10	290	2.6	3819	.20
3 ENTRY	160	2.9	25084	.02	500	.13	25084	.00	220	3.4	25084	.03	280	1.2	25084	.01
3 RUG	130	.4	18813	.00	130	.05	18813	.00	270	.45	18813	.01	500	.15	18813	.00
3 CARPORT	190	2.1	25084	.02			25084	.00	230	.6	25084	.01	400	.1	25084	.00

APPENDIX B

CHEMICAL MASS BALANCE ANALYSIS RESULTS

TACOMA SLAG STUDY

Sources Considered:

TACRD - Tacoma Road Dust
TACSD - Tacoma Soil
TACMV - Motor Vehicle Composite
TACPB - Leaded Vehicle Emissions
Kraft - Kraft Recovery Furnace
TACWD - Wood Combustion Profile
HTSLAG - House 1 Slag
GHSLAG - House 2 Slag
VRSLAG - House 3 Slag

Results:

EPAVAC - Almost perfect fit to 13 species using just the House 1 driveway slag profile, 99.7% mass explained. Also fit fairly well to the House 3 driveway slag profile.

GHVAC - Not fit by any combination of the above sources. Appears to contain very little slag. Relatively high in Ca, K, and Mn.

VRVAC - Also not fit by any combination of above sources. Relatively high in Si and Cl.

SOURCE CONTRIBUTION ESTIMATES - SITE: EPAVAC DATE: VERSION: 7.0
SAMPLE DURATION START HOUR SIZE: FINE
R SQUARE 1.00 PERCENT MASS 99.7
CHI SQUARE .12 DF 12

SOURCE *	TYPE	SCE(UG/M3)	STD ERR	TSTAT
12	HTSLAG	.9970	.0512	19.4814

MEASURED CONCENTRATION FINE/COARSE/TOTAL:
1.0+- .1/ .0+- .0/ 1.0+- .1

UNCERTAINTY/SIMILARITY CLUSTERS VERSION: 7.0 SUM OF CLUSTER SOURCES

SPECIES CONCENTRATIONS - SITE: EPAVAC DATE: VERSION: 7.0
SAMPLE DURATION START HOUR SIZE: FINE
R SQUARE 1.00 PERCENT MASS 99.7
CHI SQUARE .12 DF 12

SPECIES		I	MEAS		CALC		RATIO C/M		RATIO R/U
1	TOT	T	1.00000+-	.10000	.99704+-	.05118	1.00+-	.11	-.0
13	AL	*	.01969+-	.00277	.01970+-	.00277	1.00+-	.20	.0
14	SI	*	.12620+-	.01678	.12603+-	.01674	1.00+-	.19	.0
15	P		.00000<	.00007	.00000<	.00006	.00<	.00	.0
16	S	*	.00000<	.00139	.00000<	.00159	.00<	.00	.0
17	CL	*	.00000<	.00021	.00000<	.00023	.00<	.00	.0
19	K	*	.00419+-	.00048	.00387+-	.00044	.92+-	.15	-.5
20	CA	*	.02479+-	.00280	.02262+-	.00254	.91+-	.15	-.6
22	TI	*	.00279+-	.00028	.00266+-	.00027	.95+-	.13	-.3
23	V		.00000<	.00004	.00000<	.00003	.00<	.00	.0
24	CR		.00065+-	.00007	.00070+-	.00007	1.09+-	.15	.6
25	MN	*	.00000<	.00003	.00000<	.00002	.00<	.00	.0
26	FE	*	.17130+-	.01713	.16860+-	.01686	.98+-	.14	-.1
28	NI		.00000<	.00003	.00000<	.00002	.00<	.00	.0
29	CU		.01784+-	.00178	.01826+-	.00183	1.02+-	.14	.2
30	ZN	*	.00608+-	.00061	.00601+-	.00060	.99+-	.14	-.1
31	GA		.00000<	.00003	.00000<	.00003	.00<	.00	.0
33	AS	*	.01581+-	.00158	.01705+-	.00170	1.08+-	.15	.5
34	SE		.00000<	.00002	.00000<	.00001	.00<	.00	.0
35	BR	*	.00000<	.00006	.00000<	.00006	.00<	.00	.0
37	RB		.00000<	.00002	.00000<	.00001	.00<	.00	.0
38	SR		.00009+-	.00002	.00012+-	.00001	1.31+-	.31	1.2
39	Y		.00000<	.00002	.00000<	.00002	.00<	.00	.0
40	ZR		.00000<	.00003	.00000<	.00003	.00<	.00	.0
42	MO		.00143+-	.00014	.00139+-	.00014	.97+-	.14	-.2
46	PD		.00000<	.00013	.00003<	.00012	.00<	.00	.1
47	AG		.00000<	.00016	.00000<	.00015	.00<	.00	.0
48	CD		.00004<	.00017	.00031<	.00016	8.19<	35.65	1.2
49	IN		.00000<	.00017	.00000<	.00016	.00<	.00	.0
50	SN		.00010<	.00019	.00049<	.00018	4.71<	8.72	1.5
51	SB		.00305+-	.00030	.00342+-	.00034	1.12+-	.16	.8
56	BA		.00100+-	.00068	.00000+-	.00063	.00+-	.63	-1.1
57	LA		.00137+-	.00093	.00111+-	.00085	.81+-	.83	-.2
80	HG		.00000<	.00004	.00000<	.00003	.00<	.00	.0
82	PB	*	.00906+-	.00091	.00992+-	.00099	1.09+-	.15	.6

SOURCE CONTRIBUTION ESTIMATES - SITE: EPAVAC DATE: VERSION: 7.0
SAMPLE DURATION START HOUR SIZE: FINE
R SQUARE 1.00 PERCENT MASS 100.1
CHI SQUARE .12 DF 11

SOURCE *	TYPE	SCE(UG/M3)	STD ERR	TSTAT
06	KRAFT	.0014	.0093	.1548
12	HTSLAG	.9999	.0516	19.3964

MEASURED CONCENTRATION FINE/COARSE/TOTAL:
1.0+- .1/ .0+- .0/ 1.0+- .1

UNCERTAINTY/SIMILARITY CLUSTERS VERSION: 7.0 SUM OF CLUSTER SOURCES

SPECIES CONCENTRATIONS - SITE: EPAVAC DATE: VERSION: 7.0
SAMPLE DURATION START HOUR SIZE: FINE
R SQUARE 1.00 PERCENT MASS 100.1
CHI SQUARE .12 DF 11

SPECIES		I	MEAS		CALC		RATIO C/M		RATIO R/U
1	TOT	T	1.00000+-	.10000	1.00135+-	.05139	1.00+-	.11	.0
13	AL	*	.01969+-	.00277	.01977+-	.00278	1.00+-	.20	.0
14	SI	*	.12620+-	.01678	.12639+-	.01679	1.00+-	.19	.0
15	P		.00000<	.00007	.00000<	.00006	.00<	.00	.0
16	S	*	.00000<	.00139	.00024<	.00160	.00<	.00	.1
17	CL	*	.00000<	.00021	.00003<	.00023	.00<	.00	.1
19	K	*	.00419+-	.00048	.00391+-	.00044	.93+-	.15	-.4
20	CA	*	.02479+-	.00280	.02269+-	.00255	.92+-	.15	-.6
22	TI	*	.00279+-	.00028	.00266+-	.00027	.96+-	.14	-.3
23	V		.00000<	.00004	.00000<	.00003	.00<	.00	.0
24	CR		.00065+-	.00007	.00071+-	.00007	1.09+-	.15	.6
25	MN	*	.00000<	.00003	.00000<	.00002	.00<	.00	.0
26	FE	*	.17130+-	.01713	.16909+-	.01691	.99+-	.14	-.1
28	NI		.00000<	.00003	.00000<	.00003	.00<	.00	.0
29	CU		.01784+-	.00178	.01831+-	.00183	1.03+-	.15	.2
30	ZN	*	.00608+-	.00061	.00603+-	.00060	.99+-	.14	-.1
31	GA		.00000<	.00003	.00000<	.00003	.00<	.00	.0
33	AS	*	.01581+-	.00158	.01710+-	.00171	1.08+-	.15	.6
34	SE		.00000<	.00002	.00000<	.00001	.00<	.00	.0
35	BR	*	.00000<	.00006	.00000<	.00006	.00<	.00	.0
37	RB		.00000<	.00002	.00000<	.00001	.00<	.00	.0
38	SR		.00009+-	.00002	.00012+-	.00001	1.32+-	.31	1.2
39	Y		.00000<	.00002	.00000<	.00002	.00<	.00	.0
40	ZR		.00000<	.00003	.00000<	.00003	.00<	.00	.0
42	MO		.00143+-	.00014	.00140+-	.00014	.98+-	.14	-.2
46	PD		.00000<	.00013	.00003<	.00012	.00<	.00	.1
47	AG		.00000<	.00016	.00000<	.00015	.00<	.00	.0
48	CD		.00004<	.00017	.00031<	.00016	8.22<	36.78	1.2
49	IN		.00000<	.00017	.00000<	.00016	.00<	.00	.0
50	SN		.00010<	.00019	.00049<	.00018	4.72<	8.75	1.5
51	SB		.00305+-	.00030	.00343+-	.00034	1.12+-	.16	.8
56	BA		.00100+-	.00068	.00000+-	.00063	.00+-	.63	-1.1
57	LA		.00137+-	.00093	.00111+-	.00085	.81+-	.83	-.2
80	HG		.00000<	.00004	.00000<	.00003	.00<	.00	.0
82	PB	*	.00906+-	.00091	.00995+-	.00099	1.10+-	.16	.7

SOURCE CONTRIBUTION ESTIMATES - SITE: EPAVAC DATE: VERSION: 7.0
SAMPLE DURATION START HOUR SIZE: FINE
R SQUARE .98 PERCENT MASS 81.2
CHI SQUARE .60 DF 11

SOURCE *	TYPE	SCE(UG/M3)	STD ERR	TSTAT
06	KRAFT	.0015	.0087	.1674
10	VRSLAG	.8109	.0419	19.3512

MEASURED CONCENTRATION FINE/COARSE/TOTAL:
1.0+- .1/ .0+- .0/ 1.0+- .1

UNCERTAINTY/SIMILARITY CLUSTERS VERSION: 7.0 SUM OF CLUSTER SOURCES

SPECIES CONCENTRATIONS - SITE: EPAVAC DATE: VERSION: 7.0
SAMPLE DURATION START HOUR SIZE: FINE
R SQUARE .98 PERCENT MASS 81.2
CHI SQUARE .60 DF 11

SPECIES		I	MEAS		CALC		RATIO C/M		RATIO R/U
1	TOT	T	1.00000+-	.10000	.81232+-	.04193	.81+-	.09	-1.7
13	AL	*	.01969+-	.00277	.02687+-	.00372	1.36+-	.27	1.5
14	SI	*	.12620+-	.01678	.14742+-	.01959	1.17+-	.22	.8
15	P		.00000<	.00007	.00000<	.00006	.00<	.00	.0
16	S	*	.00000<	.00139	.00024<	.00141	.00<	.00	.1
17	CL	*	.00000<	.00021	.00003<	.00020	.00<	.00	.1
19	K	*	.00419+-	.00048	.00384+-	.00043	.92+-	.15	-.5
20	CA	*	.02479+-	.00280	.02542+-	.00286	1.03+-	.16	.2
22	TI	*	.00279+-	.00028	.00246+-	.00025	.88+-	.12	-.9
23	V		.00000<	.00004	.00000<	.00003	.00<	.00	.0
24	CR		.00065+-	.00007	.00034+-	.00003	.53+-	.07	-4.2
25	MN	*	.00000<	.00003	.00000<	.00002	.00<	.00	.0
26	FE	*	.17130+-	.01713	.15723+-	.01572	.92+-	.13	-.6
28	NI		.00000<	.00003	.00000<	.00002	.00<	.00	.0
29	CU		.01784+-	.00178	.01095+-	.00110	.61+-	.09	-3.3
30	ZN	*	.00608+-	.00061	.00684+-	.00068	1.13+-	.16	.8
31	GA		.00000<	.00003	.00000<	.00002	.00<	.00	.0
33	AS	*	.01581+-	.00158	.01342+-	.00134	.85+-	.12	-1.2
34	SE		.00000<	.00002	.00000<	.00001	.00<	.00	.0
35	BR	*	.00000<	.00006	.00000<	.00005	.00<	.00	.0
37	RB		.00000<	.00002	.00000<	.00001	.00<	.00	.0
38	SR		.00009+-	.00002	.00011+-	.00001	1.22+-	.28	.9
39	Y		.00000<	.00002	.00000<	.00001	.00<	.00	.0
40	ZR		.00000<	.00003	.00000<	.00003	.00<	.00	.0
42	MO		.00143+-	.00014	.00088+-	.00009	.61+-	.09	-3.3
46	PD		.00000<	.00013	.00008<	.00010	.00<	.00	.4
47	AG		.00000<	.00016	.00000<	.00012	.00<	.00	.0
48	CD		.00004<	.00017	.00026<	.00013	6.96<	31.16	1.1
49	IN		.00000<	.00017	.00000<	.00013	.00<	.00	.0
50	SN		.00010<	.00019	.00057<	.00015	5.52<	10.12	2.0
51	SB		.00305+-	.00030	.00363+-	.00036	1.19+-	.17	1.2
56	BA		.00100+-	.00068	.00008+-	.00051	.08+-	.51	-1.1
57	LA		.00137+-	.00093	.00000+-	.00069	.00+-	.50	-1.2
80	HG		.00000<	.00004	.00000<	.00002	.00<	.00	.0
82	PB	*	.00906+-	.00091	.00898+-	.00090	.99+-	.14	-.1

```
SOURCE CONTRIBUTION ESTIMATES -  SITE: EPAVAC       DATE:            VERSION: 7.0
SAMPLE DURATION                  START HOUR                 SIZE:    FINE
      R SQUARE       .98     PERCENT MASS       81.2
    CHI SQUARE       .55                DF        12

  SOURCE
     * TYPE     SCE(UG/M3)    STD ERR       TSTAT
---------------------------------------------
10     VRSLAG        .8116       .0417    19.4601
---------------------------------------------

MEASURED CONCENTRATION FINE/COARSE/TOTAL:
       1.0+-       .1/         .0+-       .0/        1.0+-        .1

       UNCERTAINTY/SIMILARITY CLUSTERS  VERSION: 7.0     SUM OF CLUSTER SOURCES
------------------------------------------------------------------------------

------------------------------------------------------------------------------

SPECIES CONCENTRATIONS -  SITE: EPAVAC       DATE:          VERSION: 7.0
SAMPLE DURATION                  START HOUR                 SIZE:    FINE
       R SQUARE       .98     PERCENT MASS       81.2
     CHI SQUARE       .55                DF        12
```

SPECIES		I	MEAS		CALC		RATIO C/M		RATIO R/U
1	TOT	T	1.00000+-	.10000	.81158+-	.04170	.81+-	.09	-1.7
13	AL	*	.01969+-	.00277	.02689+-	.00372	1.37+-	.27	1.6
14	SI	*	.12620+-	.01678	.14755+-	.01961	1.17+-	.22	.8
15	P		.00000<	.00007	.00000<	.00006	.00<	.00	.0
16	S	*	.00000<	.00139	.00000<	.00141	.00<	.00	.0
17	CL	*	.00000<	.00021	.00000<	.00020	.00<	.00	.0
19	K	*	.00419+-	.00048	.00381+-	.00043	.91+-	.15	-.6
20	CA	*	.02479+-	.00280	.02544+-	.00286	1.03+-	.16	.2
22	TI	*	.00279+-	.00028	.00246+-	.00025	.88+-	.12	-.9
23	V		.00000<	.00004	.00000<	.00003	.00<	.00	.0
24	CR		.00065+-	.00007	.00034+-	.00003	.53+-	.07	-4.2
25	MN	*	.00000<	.00003	.00000<	.00002	.00<	.00	.0
26	FE	*	.17130+-	.01713	.15737+-	.01574	.92+-	.13	-.6
28	NI		.00000<	.00003	.00000<	.00002	.00<	.00	.0
29	CU		.01784+-	.00178	.01096+-	.00110	.61+-	.09	-3.3
30	ZN	*	.00608+-	.00061	.00685+-	.00068	1.13+-	.16	.8
31	GA		.00000<	.00003	.00000<	.00002	.00<	.00	.0
33	AS	*	.01581+-	.00158	.01343+-	.00134	.85+-	.12	-1.1
34	SE		.00000<	.00002	.00000<	.00001	.00<	.00	.0
35	BR	*	.00000<	.00006	.00000<	.00005	.00<	.00	.0
37	RB		.00000<	.00002	.00000<	.00001	.00<	.00	.0
38	SR		.00009+-	.00002	.00011+-	.00001	1.22+-	.28	.9
39	Y		.00000<	.00002	.00000<	.00001	.00<	.00	.0
40	ZR		.00000<	.00003	.00000<	.00003	.00<	.00	.0
42	MO		.00143+-	.00014	.00088+-	.00009	.61+-	.09	-3.3
46	PD		.00000<	.00013	.00007<	.00010	.00<	.00	.4
47	AG		.00000<	.00016	.00000<	.00012	.00<	.00	.0
48	CD		.00004<	.00017	.00026<	.00013	6.96<	31.16	1.1
49	IN		.00000<	.00017	.00000<	.00013	.00<	.00	.0
50	SN		.00010<	.00019	.00057<	.00015	5.52<	10.12	2.0
51	SB		.00305+-	.00030	.00363+-	.00036	1.19+-	.17	1.2
56	BA		.00100+-	.00068	.00008+-	.00051	.08+-	.51	-1.1
57	LA		.00137+-	.00093	.00000+-	.00069	.00+-	.50	-1.2
80	HG		.00000<	.00004	.00000<	.00002	.00<	.00	.0
82	PB	*	.00906+-	.00091	.00898+-	.00090	.99+-	.14	-.1

SOURCE CONTRIBUTION ESTIMATES - SITE: GHVAC DATE: VERSION: 7.0
SAMPLE DURATION START HOUR SIZE: FINE
R SQUARE .84 PERCENT MASS 38.0
CHI SQUARE 13.64 DF 5

SOURCE * TYPE		SCE(UG/M3)	STD ERR	TSTAT
01	TACRD	.2351	.0236	9.9814
02	TACSD	.0257	.0046	5.5498
06	KRAFT	.1190	.0153	7.7556

MEASURED CONCENTRATION FINE/COARSE/TOTAL:
1.0+- .1/ .0+- .0/ 1.0+- .1

UNCERTAINTY/SIMILARITY CLUSTERS VERSION: 7.0 SUM OF CLUSTER SOURCES

SPECIES CONCENTRATIONS - SITE: GHVAC DATE: VERSION: 7.0
SAMPLE DURATION START HOUR SIZE: FINE
R SQUARE .84 PERCENT MASS 38.0
CHI SQUARE 13.64 DF 5

SPECIES		I	MEAS		CALC		RATIO C/M		RATIO R/U
1	TOT	T	1.00000+-	.10000	.37987+-	.02555	.38+-	.05	-6.0
13	AL	*	.01525+-	.00207	.02210+-	.00184	1.45+-	.23	2.5
14	SI	*	.05490+-	.00729	.06737+-	.00637	1.23+-	.20	1.3
15	P		.00055+-	.00014	.00054+-	.00018	.98+-	.42	-.0
16	S	*	.02174+-	.00246	.02054+-	.00200	.95+-	.14	-.4
17	CL	*	.00246+-	.00035	.00262+-	.00040	1.06+-	.22	.3
19	K		.02522+-	.00284	.00479+-	.00034	.19+-	.03	-7.2
20	CA		.09309+-	.01045	.00598+-	.00057	.06+-	.01	-8.3
22	TI	*	.00325+-	.00033	.00128+-	.00011	.39+-	.05	-5.7
23	V		.00007+-	.00004	.00006+-	.00001	.92+-	.52	-.1
24	CR		.00024+-	.00002	.00012+-	.00001	.53+-	.08	-4.0
25	MN		.00115+-	.00012	.00025+-	.00002	.21+-	.03	-7.7
26	FE	*	.01808+-	.00181	.01356+-	.00122	.75+-	.10	-2.1
28	NI		.00006+-	.00001	.00007+-	.00005	1.24+-	.91	.3
29	CU		.00057+-	.00006	.00035+-	.00003	.63+-	.08	-3.4
30	ZN	*	.00180+-	.00018	.00103+-	.00008	.57+-	.07	-3.9
31	GA		.00000<	.00001	.00001<	.00000	.00<	.00	.7
33	AS		.00033+-	.00004	.00008+-	.00002	.23+-	.06	-6.6
34	SE		.00000<	.00001	.00001<	.00001	.00<	.00	1.4
35	BR		.00018+-	.00002	.00009+-	.00001	.52+-	.09	-3.9
37	RB		.00003+-	.00001	.00004+-	.00001	1.34+-	.55	.7
38	SR		.00052+-	.00005	.00010+-	.00001	.20+-	.03	-7.9
39	Y		.00000<	.00001	.00001<	.00000	.00<	.00	1.1
40	ZR		.00021+-	.00002	.00004+-	.00003	.19+-	.14	-4.6
42	MO		.00002+-	.00002	.00003+-	.00002	1.25+-	1.18	.2
46	PD		.00000<	.00006	.00004<	.00002	.00<	.00	.7
47	AG		.00003<	.00008	.00004<	.00003	1.33<	3.34	.1
48	CD		.00010+-	.00008	.00004+-	.00002	.44+-	.43	-.6
49	IN		.00000<	.00010	.00007<	.00007	.00<	.00	.6
50	SN		.00000<	.00012	.00007<	.00002	.00<	.00	.6
51	SB		.00000<	.00014	.00007<	.00007	.00<	.00	.4
56	BA		.00163+-	.00056	.00022+-	.00013	.14+-	.09	-2.5
57	LA		.00133+-	.00074	.00037+-	.00027	.28+-	.25	-1.2
80	HG		.00000<	.00001	.00001<	.00000	.00<	.00	.6
82	PB	*	.00051+-	.00005	.00071+-	.00005	1.40+-	.17	2.8

SOURCE CONTRIBUTION ESTIMATES - SITE: VRVAC DATE: VERSION: 7.0
SAMPLE DURATION START HOUR SIZE: FINE
R SQUARE .74 PERCENT MASS 35.5
CHI SQUARE 22.08 DF 5

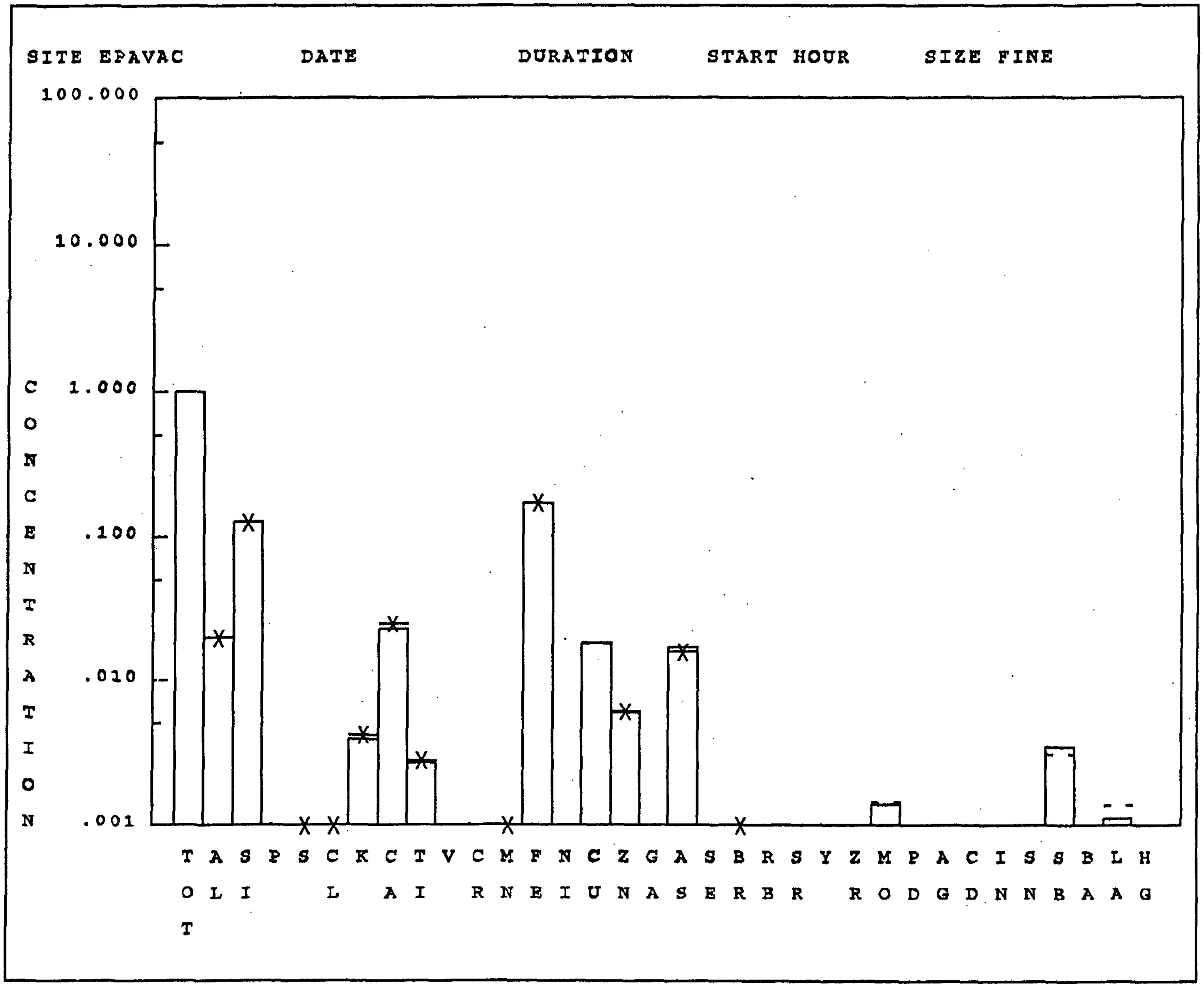
SOURCE *	TYPE	SCE(UG/M3)	STD ERR	TSTAT
01	TACRD	.2740	.0260	10.5459
02	TACSD	.0107	.0036	2.9421
06	KRAFT	.0701	.0096	7.3248

MEASURED CONCENTRATION FINE/COARSE/TOTAL:
1.0+- .1/ .0+- .0/ 1.0+- .1

UNCERTAINTY/SIMILARITY CLUSTERS VERSION: 7.0 SUM OF CLUSTER SOURCES

SPECIES CONCENTRATIONS - SITE: VRVAC DATE: VERSION: 7.0
SAMPLE DURATION START HOUR SIZE: FINE
R SQUARE .74 PERCENT MASS 35.5
CHI SQUARE 22.08 DF 5

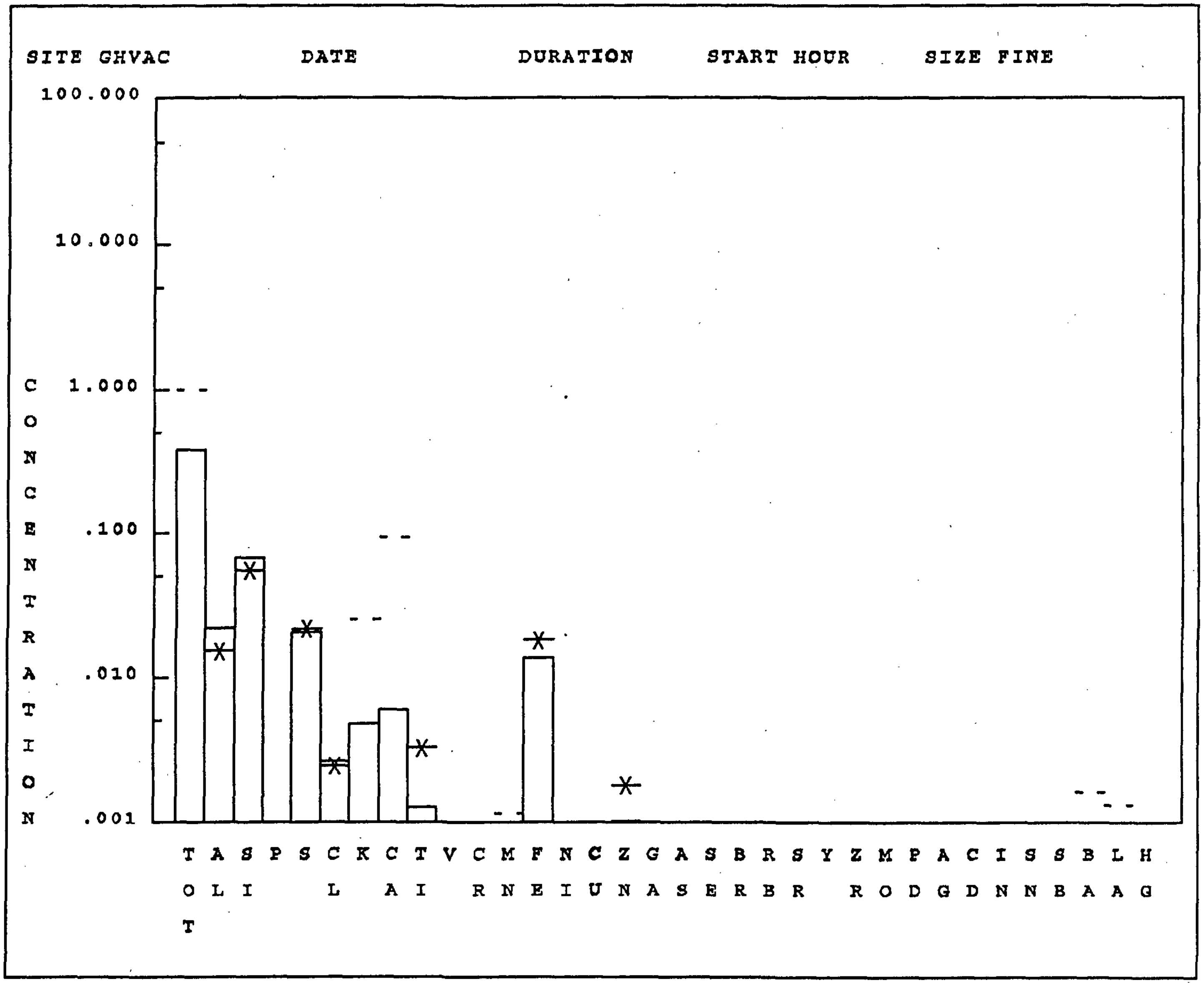
SPECIES		I	MEAS		CALC		RATIO C/M		RATIO R/U
1	TOT	T	1.00000+-	.10000	.35483+-	.02523	.35+-	.04	-6.3
13	AL	*	.01476+-	.00206	.02240+-	.00206	1.52+-	.25	2.6
14	SI	*	.08365+-	.01116	.07570+-	.00740	.90+-	.15	-.6
15	P		.00000<	.00007	.00050<	.00013	.00<	.00	3.4
16	S	*	.01005+-	.00117	.01244+-	.00118	1.24+-	.19	1.4
17	CL	*	.00588+-	.00069	.00165+-	.00024	.28+-	.05	-5.8
19	K		.00872+-	.00099	.00392+-	.00028	.45+-	.06	-4.7
20	CA		.04664+-	.00528	.00673+-	.00066	.14+-	.02	-7.5
22	TI	*	.00355+-	.00035	.00137+-	.00013	.39+-	.05	-5.8
23	V		.00004<	.00004	.00007<	.00001	1.94<	2.25	.8
24	CR		.00027+-	.00003	.00012+-	.00001	.43+-	.06	-5.2
25	MN		.00027+-	.00003	.00026+-	.00002	.96+-	.13	-.3
26	FE	*	.01630+-	.00163	.01461+-	.00139	.90+-	.12	-.8
28	NI		.00003+-	.00001	.00006+-	.00003	1.97+-	1.35	.9
29	CU		.00069+-	.00007	.00025+-	.00002	.37+-	.05	-6.1
30	ZN	*	.00124+-	.00012	.00064+-	.00005	.52+-	.06	-4.5
31	GA		.00000<	.00001	.00000<	.00000	.00<	.00	.4
33	AS		.00017+-	.00003	.00009+-	.00002	.52+-	.15	-2.4
34	SE		.00000<	.00001	.00001<	.00000	.00<	.00	1.0
35	BR		.00004+-	.00001	.00006+-	.00001	1.61+-	.44	2.0
37	RB		.00000<	.00001	.00003<	.00001	9.31<	37.30	1.9
38	SR		.00014+-	.00002	.00011+-	.00001	.81+-	.13	-1.3
39	Y		.00000<	.00002	.00001<	.00000	.00<	.00	.7
40	ZR		.00174+-	.00017	.00003+-	.00002	.01+-	.01	-9.8
42	MO		.00002<	.00003	.00003<	.00001	1.46<	2.56	.3
46	PD		.00000<	.00008	.00003<	.00001	.00<	.00	.3
47	AG		.00018+-	.00010	.00003+-	.00002	.18+-	.15	-1.4
48	CD		.00024+-	.00012	.00003+-	.00001	.11+-	.08	-1.8
49	IN		.00000<	.00014	.00005<	.00004	.00<	.00	.3
50	SN		.00017<	.00018	.00004<	.00002	.23<	.26	-.7
51	SB		.00058+-	.00022	.00004+-	.00005	.08+-	.08	-2.3
56	BA		.00033<	.00086	.00015<	.00009	.47<	1.25	-.2
57	LA		.00039<	.00119	.00025<	.00017	.64<	2.02	-.1
80	HG		.00000<	.00002	.00001<	.00000	.00<	.00	.4
82	PB	*	.00032+-	.00004	.00052+-	.00004	1.64+-	.24	3.6



Solid Bars are Calculated concentrations.

Dashed Lines are Measured Concentrations.

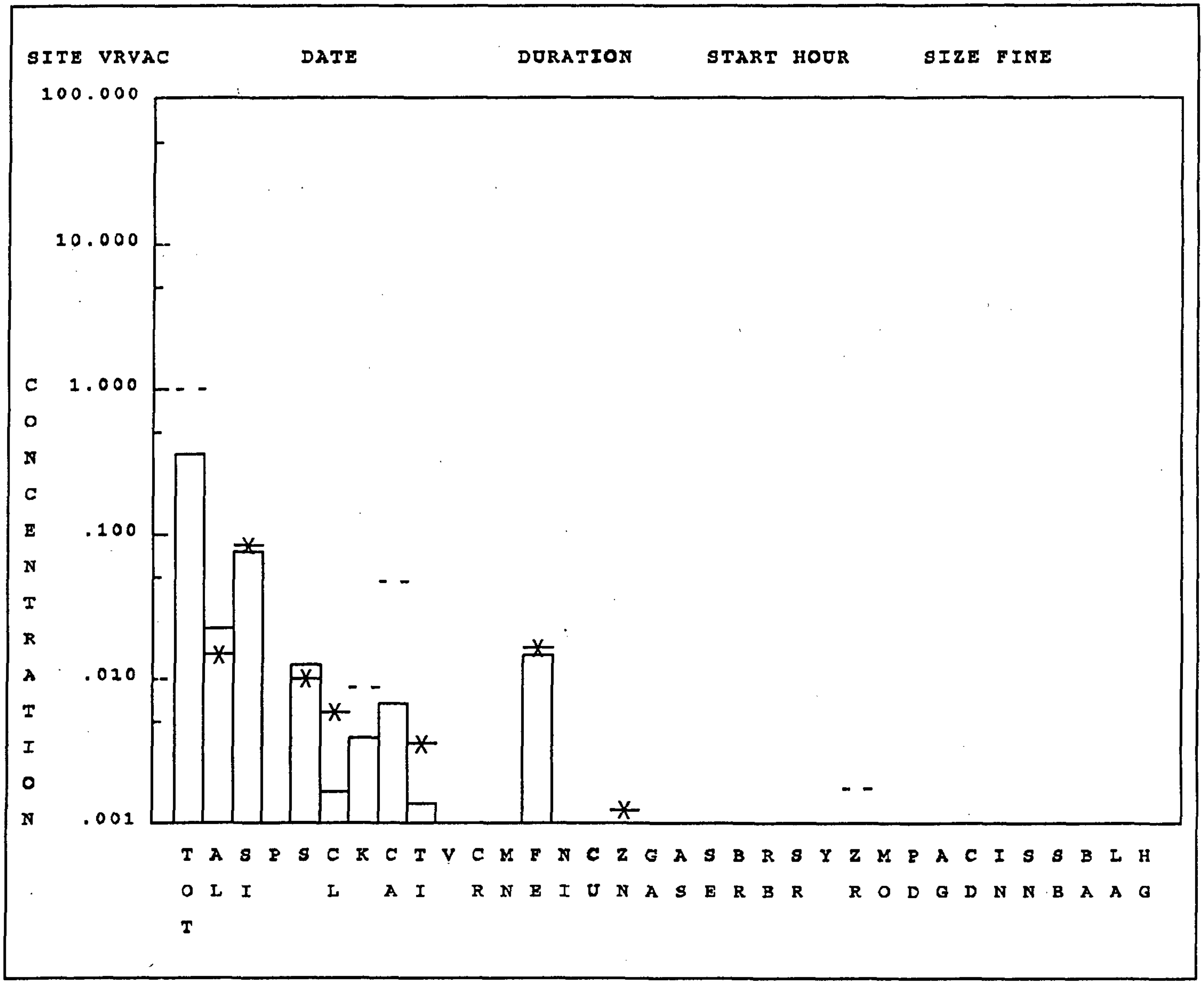
Asterisk are the Fitting Species



Solid Bars are Calculated concentrations.

Dashed Lines are Measured Concentrations.

Asterisk are the Fitting Species



Solid Bars are Calculated concentrations.

Dashed Lines are Measured Concentrations.

… are the Fitting Species

srce code	part size	revsion date	source description	reference author	reference date
5712	T	01/17/91	Tacoma/House 3 Hsehld Vacuum	Wade, John	01/91
5713	T	01/17/91	Gig Harbor/House 2 Hsehld Vac	Wade, John	01/91
5714	T	01/17/91	Gig Harbor/House 2 EPA Vac	Wade, John	01/91
5715	T	01/17/91	Tacoma/House 3 Driveway Slag	Wade, John	01/91
5716	T	01/17/91	Gig Harbor/House 2 Drvwy Slag	Wade, John	01/91
5717	T	01/17/91	Tacoma/House 1 Driveway Slag	Wade, John	01/91

srce code	part size	revsion date	source description	reference author	reference date
5712	T	01/17/91	Tacoma/House 3 Hsehld Vacuum	Wade, John	01/91

PERCENT COMPOSITION

SPECIES	FINE	COARSE	TOTAL
Al			1.4760 +- .2064
Si			8.3650 +- 1.1160
P			.0000 +- .0074
S			1.0050 +- .1172
Cl			.5879 +- .0692
K			.8720 +- .0993
Ca			4.6640 +- .5278
Ti			.3554 +- .0355
V			.0035 +- .0040
Cr			.0270 +- .0027
Mn			.0269 +- .0027
Fe			1.6300 +- .1630
Ni			.0029 +- .0013
Cu			.0694 +- .0069
Zn			.1240 +- .0124
Ga			.0000 +- .0010
As			.0166 +- .0028
Se			.0000 +- .0008
Br			.0040 +- .0010
Rb			.0003 +- .0012
Sr			.0142 +- .0017
Y			.0000 +- .0019
Zr			.1741 +- .0174
Mo			.0020 +- .0034
Pd			.0000 +- .0082
Ag			.0183 +- .0104
Cd			.0244 +- .0122
In			.0000 +- .0143
Sn			.0171 +- .0178
Sb			.0576 +- .0223
Ba			.0328 +- .0857
La			.0387 +- .1188
Hg			.0000 +- .0016
Pb			.0319 +- .0040
Sum			19.6410

srce code	part size	revsion date	source description	reference author	date
5713	T	01/17/91	Gig Harbor/House 2 Hsehld Vac	Wade, John	01/91

SPECIES	PERCENT COMPOSITION FINE	COARSE	TOTAL
Al			1.5250 +- .2075
Si			5.4900 +- .7292
P			.0549 +- .0144
S			2.1740 +- .2461
Cl			.2456 +- .0345
K			2.5220 +- .2837
Ca			9.3090 +- 1.0450
Ti			.3248 +- .0325
V			.0070 +- .0037
Cr			.0236 +- .0024
Mn			.1151 +- .0115
Fe			1.8080 +- .1808
Ni			.0057 +- .0011
Cu			.0566 +- .0057
Zn			.1803 +- .0180
Ga			.0000 +- .0008
As			.0335 +- .0035
Se			.0000 +- .0006
Br			.0180 +- .0018
Rb			.0027 +- .0009
Sr			.0524 +- .0052
Y			.0000 +- .0012
Zr			.0208 +- .0023
Mo			.0025 +- .0020
Pd			.0000 +- .0062
Ag			.0031 +- .0075
Cd			.0096 +- .0083
In			.0000 +- .0096
Sn			.0000 +- .0118
Sb			.0000 +- .0143
Ba			.1626 +- .0557
La			.1332 +- .0740
Hg			.0000 +- .0012
Pb			.0507 +- .0051
Sum			24.3307

srce code	part size	revsion date	source description	reference author	date
5714	T	01/17/91	Gig Harbor/House 2 EPA Vacuum	Wade, John	01/91

PERCENT COMPOSITION

SPECIES	FINE	COARSE	TOTAL
Al			1.9690 +- .2768
Si			12.6200 +- 1.6780
P			.0000 +- .0066
S			.0000 +- .1391
Cl			.0000 +- .0213
K			.4186 +- .0478
Ca			2.4790 +- .2795
Ti			.2785 +- .0278
V			.0000 +- .0036
Cr			.0648 +- .0065
Mn			.0000 +- .0026
Fe			17.1300 +- 1.7130
Ni			.0000 +- .0030
Cu			1.7840 +- .1784
Zn			.6081 +- .0608
Ga			.0000 +- .0028
As			1.5810 +- .1581
Se			.0000 +- .0017
Br			.0000 +- .0061
Rb			.0000 +- .0017
Sr			.0088 +- .0017
Y			.0000 +- .0020
Zr			.0000 +- .0032
Mo			.1430 +- .0143
Pd			.0000 +- .0134
Ag			.0000 +- .0155
Cd			.0038 +- .0169
In			.0000 +- .0171
Sn			.0104 +- .0189
Sb			.3049 +- .0305
Ba			.1001 +- .0685
La			.1372 +- .0927
Hg			.0000 +- .0036
Pb			.9062 +- .0906
Sum			40.5474

srce code	part size	revsion date	source description	reference author	date
5715	T	01/17/91	Tacoma/House 3 Driveway Slag	Wade, John	01/91

	PERCENT	COMPOSITION	
SPECIES	FINE	COARSE	TOTAL
Al			3.3130 +- .4584
Si			18.1800 +- 2.4160
P			.0000 +- .0070
S			.0000 +- .1733
Cl			.0000 +- .0248
K			.4689 +- .0534
Ca			3.1350 +- .3527
Ti			.3032 +- .0303
V			.0000 +- .0038
Cr			.0421 +- .0042
Mn			.0000 +- .0027
Fe			19.3900 +- 1.9390
Ni			.0000 +- .0024
Cu			1.3510 +- .1351
Zn			.8440 +- .0844
Ga			.0000 +- .0027
As			1.6550 +- .1655
Se			.0000 +- .0015
Br			.0000 +- .0064
Rb			.0000 +- .0015
Sr			.0132 +- .0016
Y			.0000 +- .0018
Zr			.0000 +- .0034
Mo			.1081 +- .0108
Pd			.0092 +- .0127
Ag			.0000 +- .0148
Cd			.0326 +- .0163
In			.0000 +- .0160
Sn			.0707 +- .0179
Sb			.4477 +- .0448
Ba			.0097 +- .0626
La			.0000 +- .0853
Hg			.0000 +- .0030
Pb			1.1070 +- .1107
Sum			50.4804

srce code	part size	revsion date	source description	reference author	date
5716	T	01/17/91	Gig Harbor/House 2 Drvwy Slag	Wade, John	01/91

PERCENT COMPOSITION

SPECIES	FINE	COARSE	TOTAL
Al			1.5380 +- .2221
Si			11.9500 +- 1.5880
P			.0000 +- .0063
S			.0000 +- .1546
Cl			.0000 +- .0227
K			.3043 +- .0350
Ca			2.6290 +- .2961
Ti			.2494 +- .0249
V			.0000 +- .0034
Cr			.0352 +- .0035
Mn			.0000 +- .0026
Fe			19.5600 +- 1.9560
Ni			.0000 +- .0027
Cu			1.8710 +- .1871
Zn			1.3990 +- .1399
Ga			.0000 +- .0031
As			4.6160 +- .4616
Se			.0000 +- .0022
Br			.0000 +- .0165
Rb			.0000 +- .0024
Sr			.0045 +- .0016
Y			.0000 +- .0019
Zr			.0000 +- .0038
Mo			.1750 +- .0175
Pd			.0306 +- .0153
Ag			.0296 +- .0169
Cd			.0365 +- .0183
In			.0000 +- .0184
Sn			.0370 +- .0202
Sb			.5535 +- .0553
Ba			.0008 +- .0651
La			.0000 +- .0902
Hg			.0000 +- .0036
Pb			1.1620 +- .1162
Sum			46.1814

srce code	part size	revsion date	source description	reference author	reference date
5717	T	01/17/91	Tacoma/House 1 Driveway Slag	Wade, John	01/91

PERCENT COMPOSITION

SPECIES	FINE	COARSE	TOTAL
Al			1.9760 +- .2776
Si			12.6400 +- 1.6790
P			.0000 +- .0063
S			.0000 +- .1595
Cl			.0000 +- .0227
K			.3879 +- .0442
Ca			2.2690 +- .2552
Ti			.2663 +- .0266
V			.0000 +- .0034
Cr			.0706 +- .0071
Mn			.0000 +- .0025
Fe			16.9100 +- 1.6910
Ni			.0000 +- .0025
Cu			1.8310 +- .1831
Zn			.6032 +- .0603
Ga			.0000 +- .0026
As			1.7100 +- .1710
Se			.0000 +- .0015
Br			.0000 +- .0065
Rb			.0000 +- .0014
Sr			.0116 +- .0015
Y			.0000 +- .0017
Zr			.0000 +- .0032
Mo			.1396 +- .0140
Pd			.0027 +- .0125
Ag			.0000 +- .0146
Cd			.0312 +- .0160
In			.0000 +- .0161
Sn			.0491 +- .0178
Sb			.3426 +- .0343
Ba			.0000 +- .0629
La			.1111 +- .0853
Hg			.0000 +- .0027
Pb			.9949 +- .0995
Sum			40.3468

APPENDIX C

CHAIN OF CUSTODY RECORD
FOR FIELD SAMPLING

NOTE: In this section, for confidentiality, house addresses are covered and replaced with House 1, House 2 or House 3. The addresses remain on the original chain of custody.

NEA, INC.
10950 S.W. 5TH STREET SUITE 310
BEAVERTON, OREGON 97005
Phone (503)643-4661
Fax (503)643-4039

CHAIN OF CUSTODY RECORD

PROJECT NO: 316-001

PROJECT NAME: TACOMA Slag STUDY

SAMPLERS (Signature): Rik Hanna, Dan Redline, John E Wade

REMARKS: Floor = 20 x 20 cm = 2580 cm^2; Refrig = 10 x 10 in = 645 cm^2

SAMPLE IDENTIFICATION	DATE	TIME	~~GRAB~~ Wipe	~~COMP~~ Blank	REMARKS
Refridge TS1127901	11/27	11:00	✓		House1-Tacoma
Floor TS1127902	11/27	11:25	✓		
Carpet TS1127903	11/27	11:30	✓		
Vacuum TS1127904	11/27	12:15	✓		
Vacuum Rinse TS1127905	11/27	12:30		✓	
Driveway Slag TS1127906	11/27	12:40	Grab ✓		
Driveway Slag TS1127907	11/27	1300	✓		
Yard Composite #1 TS1127908	11/27	1300		comp ✓	
Yard #2 TS1127909	11/27	13:15		✓	
Yard #3 TS1127910	11/27	13:30		✓	
Yard #4 TS1127911	11/27	13:45		✓	
Soil Core Rinse TS1127912	11/27	1400	Blank		

QS ✓ Grab

TOTAL NO. OF CONTAINERS: 12

Relinquished by:	Date / Time	Received by: (Signature)	Relinquished by:	Date/Time	Received by: (Signature)
D. Redline	11/27/90 2300	John E Wade	John E Wade	11/28 7:40	D. Redline
D. Redline	11/28/90 1830	Rick M. Hanna	Rick Hanna	11/29/90 1620	Jack Sheets

Method of Shipment:	Date Shipped	Shipped by: (Signature)	Courier (Signature)	Received for Lab. by:	Date/Time

Distribution: Original Accompanies Shipment; Copy to Field Files

A, INC.
10950 S.W. 5TH STREET SUITE 310
BEAVERTON, OREGON 97005
Phone (503) 643-4661
Fax (503) 643-4039

CHAIN OF CUSTODY RECORD

PROJECT NO	PROJECT NAME
316-001	TACOMA SLAG STUDY

SAMPLERS (Signature): Rick Hanna, Dan Redling, John E Wade

SAMPLE IDENTIFICATION	DATE	TIME	GRAB	COMP	REMARKS
Yard Soil #1 TS1127913	11/27	4:30		✓	House 2-Gig Harbor
Yard Soil #2 TS1127914	11/27	4:40		✓	
Yard Soil #3 TS1127917	11/27	4:50		✓	
Yard Soil #4 TS1127918	11/27	5:00		✓	
Driveway Slag #1 TS1127915	11/27	4:30	✓		
Driveway Slag #2 TS1127916	11/27	4:50	✓		
Spatula Rinse TS1127919	11/27	5:20	blank		
Soil Core Samp. Rinse H2O TS1127920	11/27	5:30	blank		

TOTAL NO. OF CONTAINERS: 8

Relinquished by:	Date / Time	Received by: (Signature)	Relinquished by:	Date/Time	Received by: (Signature)
D. Redling	11/27/90 2300	John E. Wade	John E Wade	11/28/90 1140	D. Redling
D. Redling	11/27/90 1830	Rick M. Hanna	Rick M. Hanna	11/29/90 1620	Jack Sheets

Method of Shipment:	Date Shipped	Shipped by: (Signature)	Courier (Signature)	Received for Lab. by:	Date/Time

Distribution: Original Accompanies Shipment; Copy to Field Files

_A, INC.
10950 S.W. 5TH STREET SUITE 310
BEAVERTON, OREGON 97005
Phone (503)643-4661
Fax (503)643-4039

CHAIN OF CUSTODY RECORD

PROJECT NO: 316-001

PROJECT NAME: TACOMA SLAG STUDY

SAMPLERS (Signature): Rick Hanna

REMARKS: House 2 - Gig Harbor

	SAMPLE IDENTIFICATION	DATE	TIME	~~GRAB~~ Wipe	~~COMP~~ Grab
	Refrig Top Wipe TS1127921	11/27	2045	✓	
#1	Kitchen floor wipe TS1127922	11/27	2100	✓	
	Floor wipe blank TS1127923	11/27	2120	Blank	
#2	Kitchen floor wipe TS1127924	11/27	2115	✓	
	Vacuum Grab Sample TS1127925	11/27	2115		✓
Vacuum	Carpet Sample TS1127926	11/27	2130		✓
	Entry Carpet Vac Sample TS1127927	11/27	2145		✓
	Vacuum Rinse Bottle TS1127928	11/27	2130		Blank
	Vacuum mat Rinse TS1127929	11/27	2150		Blank

TOTAL NO. OF CONTAINERS: 9

Relinquished by:	Date / Time	Received by: (Signature)	Relinquished by:	Date/Time	Received by: (Signature)
Rick Hanna	11/29/90 1620	Jack Sheets			

Relinquished by:	Date / Time	Received by: (Signature)	Relinquished by:	Date/Time	Received by: (Signature)

Method of Shipment:	Date Shipped	Shipped by: (Signature)	Courier (Signature)	Received for Lab. by:	Date/Time

Distribution: Original Accompanies Shipment; Copy to Field Files

A NC.
10950 S.W. 5TH STREET SUITE 310
BEAVERTON, OREGON 97005
Phone (503)643-4661
Fax (503)643-4039

CHAIN OF CUSTODY RECORD

PROJECT NO	PROJECT NAME	REMARKS
316-001	TACOMA SLAG STUDY	P. 1/2

SAMPLERS (Signature) Rick M. Hanna Dan Redline [illegible]

SAMPLE IDENTIFICATION	DATE	TIME	GRAB	COMP	REMARKS
Yard Soil #1 TS1127930	11/28	9:00		✓	House 3 - Tacoma
Yard Soil #2 TS1127931	11/28	9:10		✓	
Yard Soil #3 TS1127932	11/28	9:15		✓	
Yard Soil #4 TS1127933	11/28	9:30		✓	
Yard Soil #5 TS1127934	11/28	10:00		✓	
Driveway Slag #1 TS1127935	11/28	9:45	✓		
Driveway Slag #2 TS1127936	11/28	1000	✓		
Wash-Corer TS1127937	11/28	1030		blank	
Wash-Spatula TS1127938	11/28	1030		blank	
Vac-Household TS1127939	11/28	1045	✓		
Vinyl Floor Wipe TS1127940	11/28	1120	✓		
Entry Way Carpet TS1127941	11/28	1130		✓	
Freezer Top Wipe #1 TS1127942	11/28	1130	✓		
Family Room Carpet TS1127943	11/28	1230		✓	
Freezer Top Wipe #2 TS1127944	11/28	1130	✓		

TOTAL NO. OF CONTAINERS: 15

Relinquished by:	Date / Time	Received by: (Signature)	Relinquished by:	Date/Time	Received by: (Signature)
Rick Hanna	11/29/90 1620	Jack Sheets			

Relinquished by:	Date / Time	Received by: (Signature)	Relinquished by:	Date/Time	Received by: (Signature)

Method of Shipment:	Date Shipped	Shipped by: (Signature)	Courier (Signature)	Received for Lab. by:	Date/Time

Distribution: Original Accompanies Shipment; Copy to Field Files

.A, INC.
10950 S.W. 5TH STREET SUITE 310
BEAVERTON, OREGON 97005
Phone (503)643-4661
Fax (503)643-4039

CHAIN OF CUSTODY RECORD

PROJECT NO	PROJECT NAME	REMARKS
316-001	TACOMA SLAG STUDY	p. 2/2

SAMPLERS (Signature) Kirk M. Hanna, Dan Redding, John E Wa...

SAMPLE IDENTIFICATION	DATE	TIME	GRAB	COMP	REMARKS
Trip Wipe Blank TS1127945	11/28	1130		blank	House 3 - Tacoma
Entry Bottle wash TS1127946	11/28	1200	✓		
Fam. Rm. Bottle wash TS1127947	11/28	1300	✓		
Garage Vac TS1127948	11/28	1300	✓		
Garage Bottle wash TS1127949	11/28	1315	✓		

TOTAL NO. OF CONTAINERS 5

Relinquished by:	Date / Time	Received by: (Signature)	Relinquished by:	Date/Time	Received by: (Signature)
Kirk Hanna	11/29/90 1620	Jack Sheets			

Relinquished by:	Date / Time	Received by: (Signature)	Relinquished by:	Date/Time	Received by: (Signature)

Method of Shipment:	Date Shipped	Shipped by: (Signature)	Courier (Signature)	Received for Lab. by:	Date/Time

Distribution: Original Accompanies Shipment; Copy to Field Files

~~KEA, INC.~~
10950 S.W. 5TH STREET SUITE 310
BEAVERTON, OREGON 97005
Phone (503)643-4661
Fax (503)643-4039

CHAIN OF CUSTODY RECORD

PROJECT NO	PROJECT NAME				
316-001	Tacoma Slag Study				

SAMPLERS (Signature) John E Wade

SAMPLE IDENTIFICATION	DATE	TIME	GRAB	COMP	REMARKS
					Address — EPA #
Slag 2/1 Driveway TS1127950	12/14	9:30	✓		House 2 — 48115
Slag 2/2 Driveway TS1127951	12/14	10:05	✓		Gig Harbor 48116
Rinse TS1127952	12/14	10:22	Blank Rinse		48114
Slag 3/1 Driveway TS1127953	12/14	11:23	✓		House 3 — 48112
Slag 3/2 Driveway TS1127954	12/14	11:56	✓		Tacoma 48113
Trip Blank Bucket Rinse TS1127955	12/14	4:30	Rinse		

TOTAL NO. OF CONTAINERS

Relinquished by:	Date / Time	Received by: (Signature)	Relinquished by:	Date/Time	Received by: (Signature)
John E Wade	12/14/90 1628	Rick M. Hanna	Rick M. Hanna	12-21-90 1330	Jack Sheet
Relinquished by:	Date / Time	Received by: (Signature)	Relinquished by:	Date/Time	Received by: (Signature)
Method of Shipment:	Date Shipped	Shipped by: (Signature)	Courier (Signature)	Received for Lab. by:	Date/Time

Distribution: Original Accompanies Shipment; Copy to Field Files

EA, INC.
10950 S.W. 5TH STREET SUITE 310
BEAVERTON, OREGON 97005
Phone (503) 643-4661
Fax (503) 643-4039

CHAIN OF CUSTODY RECORD

PROJECT NO: 316-001

PROJECT NAME: Tacoma Slag

SAMPLERS (Signature)

REMARKS: TACOMA SLAG STUDY QUALITY Assurance

SAMPLE IDENTIFICATION	DATE	TIME	GRAB	COMP	[illegible]	GFAA/ICP As, Pb				LIMS		ID				REMARKS
TS1127956/CM1	12/17				✓	✓			90	S.	149					Quality Assurance Sample
TS1127957/CM2	12/17				✓	✓				-	150					Quality Assurance Sample

TOTAL NO. OF CONTAINERS

Relinquished by: [signature]	Date / Time	Received by: (Signature)	Relinquished by:	Date/Time	Received by: (Signature)
Relinquished by:	Date / Time	Received by: (Signature)	Relinquished by:	Date/Time	Received by: (Signature)
Method of Shipment:	Date Shipped	Shipped by: (Signature)	Courier (Signature)	Received for Lab. by:	Date/Time

Distribution: Original Accompanies Shipment; Copy to Field Files

EA, INC.
10~~900 S.W. 5TH STREET SUITE~~ 310
BEAVERTON, OREGON 97005
Phone (503) 643-4661
Fax (503) 643-4039

CHAIN OF CUSTODY RECORD

PROJECT NO	PROJECT NAME					ICP/GFAA	REMARKS
316-001	Tacoma Slag Study						
SAMPLERS	(Signature)						
SAMPLE IDENTIFICATION	DATE	TIME	~~GRAB~~ Std	COMP			
TS1127958/STD3	12/26/90		✓			✓	These are two standards for
TS1127959/STD4	12/26/90		✓			✓	accuracy checks
					TOTAL NO. OF CONTAINERS		

Relinquished by:	Date / Time	Received by: (Signature)	Relinquished by:	Date/Time	Received by: (Signature)
[signature]					
Relinquished by:	Date / Time	Received by: (Signature)	Relinquished by:	Date/Time	Received by: (Signature)
Method of Shipment:	Date Shipped	Shipped by: (Signature)	Courier (Signature)	Received for Lab. by:	Date/Time

Distribution: Original Accompanies Shipment; Copy to Field Files